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A TOTEM POLE, ALERT BAY, VANCOUVER ISLAND.

WOODEN MONUMENTS OF THE NORTHWEST COAST INDIANS.—[See page 248.]

ALCOHOL FROM WOOD WASTE.*

ITS CHEMISTRY AND PROCESSES.

BY PROF. R. F. RUTTAN, M. D.

The action of the zymase of yeast upon glucose and certain other fermentable sugars is the one source of the ethyl alcohol of commerce. It therefore follows that the problem of how to produce ethyl alcohol in a more economic manner can only be solved by finding a new and cheaper method of obtaining solutions of fermentable sugars.

The fermentable sugars employed in the preparation of alcohol have been derived hitherto from a number of sources, which may be generally stated to be (1) the products of the hydrolysis of starch and allied substances by means of an amylase; (2) solutions of sugar obtained directly from fruits, etc., and the non-crystallizable by-products of sugar works, etc.

The cost of alcohol from these sources is much too great to enable it to compete with other products in many fields where it could be used to great advantage. This is due, not so much to the cost of manufacture as to the cost of the raw material from which the fermentable sugar is obtained. The most economical source of starch on this continent is Indian corn, yet this raw material costs at present $21.60 per ton. One ton of corn gives about 90 gallons of alcohol of 94 per cent at a cost of 24 cents per gallon for raw material. About two gallons of raw molasses produce 1 gallon of 94 per cent alcohol, and this raw material costs 21—22 cents. The raw material of German alcohol has been estimated to cost 20 to 21 cents per gallon of alcohol of this strength.

There is a process in which a waste product of nominal commercial value is the raw material from which fermentable sugars can be obtained. The actual cost of sawdust and other wood waste to any industry is difficult to estimate. In some localities, where the quantity of waste is not great, a local market for it has been established, and in most forms it has been disposed of at a small profit. The larger mills, now that electricity is of such general application, have in many cases increased their power and find an economic outlet for all forms of wood waste as fuel for generating this power. There remains, however, the great majority of the large sawmills of this continent where the wood waste has either to be disposed of by sawdust burners at a cost of about 20 cents per ton, or allowed to accumulate in heaps upon the land, or is turned into an adjoining stream to be a nuisance and an injury for many years, if not for generations.

Any industry employing wood waste situated in the vicinity of a large mill of the last-mentioned class, should be able to obtain waste for the cost of transportation and handling which under moderately favorable conditions should not exceed 30—50 cents per ton.†

As I shall later explain, one ton of sawdust or other comminuted wood waste calculated to a dry basis can be made to yield about 20 gallons of alcohol of 94 per cent. This then reduces the cost of raw material from 20—24 cents to 2 or 2½ cents per gallon of alcohol.

That fermentable sugar can be produced from wood has been known to chemists for nearly a century. Braconnet as early as 1819, by heating wood cellulose with sulphuric acid, produced a pulp which contained glucose. The sulphuric acid, however, could not be economically removed. Since then no process has been devised until quite recently for hydrolyzing cellulose and allied bodies economically.

Numerous attempts have been made to solve this problem and the list of patents on the subject is a large one. Prior to 1900, when the Classen patents were taken out, the hydrolyzing effect of many acids on starch and the celluloses had been studied and the process patented. C. Pope, for instance, in 1898 obtained a patent for hydrolyzing starch and obtaining fermentable sugar by sulphuric acid, and Einar Simonsen in 1898 a patent to make sugar glucose from sawdust by the action of dilute sulphuric acid. Sulphurous acid had long been used to make wood pulp from comminuted wood before these patents; it was also well known that when sulphurous acid was heated with wood, sulphuric acid was always formed which took part in the reaction, and its action was prevented in pulp-making by the use of calcium bisulphite, the sulphuric acid combining with the calcium as it was produced.

Dr. Alexander Classen of the Polytechnic School of Aachen, stated in 1900 that sulphurous acid in aqueous solution under pressure converted the cellulose of wood into glucose and that the product could be fermented in the usual way yielding ethyl alcohol. He patented this process all over the world, but the original methods as stated in the patent proved to be crude and unworkable. The claim is as follows:

"The process of converting cellulose into sugar, which consists in heating the cellulose in a closed vessel at a temperature of 120 deg.—145 deg. C. with a solution of sulphurous and sulphuric acids substantially as described."

After successful experiments in a test plant erected by Classen in Aachen, a similar plant on a larger scale was erected at Highland Park near Chicago, to demonstrate to American capitalists its possibilities. The results were so satisfactory that a larger plant on a commercial scale was erected at Hattiesburg, Miss. The plant included the following elements:

1. An acid apparatus where the solution of sulphurous acid was prepared and where the excess of sulphur dioxide after use could be re-absorbed and saved for further utilization.

2. A revolving cylinder, 30 feet long, and about 36 inches in diameter, which formed the converter or digester.

3. An exhausting battery consisting of a series of tanks in which the sugar was washed from the partly converted sawdust by hot water.

4. Neutralizing vats in which the various acids remaining in the saccharine liquid were neutralized by calcium carbonate.

5. Fermentation vats, and a still, where the process was completed as in an ordinary distillery.

The wood waste was introduced into the digester (which it nearly, but not completely filled), made of iron lined with lead to prevent action of the sulphuric acid, and surrounded by a steam jacket by which it was heated. This revolving cylinder had a capacity of about two tons. To the charge of wood waste was added a weight of a nearly saturated solution of sulphur dioxide corresponding to about one-third of the raw material. The drum was closed air-tight and steam turned into the jacket while the whole slowly revolved. The temperature of the interior was thus slowly raised to 290 deg.—300 deg. F., and the pressure to about one hundred pounds. After from four to six hours the sulphurous acid and steam were blown off into the absorbing tanks and the sulphur dioxide thus partially recovered. The cover was removed and the contents emptied looking then very like finely ground coffee. This finely divided, treated wood was conveyed to the exhaustion batteries and the sugar extracted. The liquid obtained, contained from 350—400 pounds of sugar for each ton of raw material treated. The next steps were to neutralize the acid liquid, allow it to clear by subsidence, pump it into the fermentation vats, ferment it by yeast and distill the product in the usual way. It was claimed for the process that each ton of wood waste gave about 18—20 gallons of absolute alcohol.

The history of the original Classen process is an excellent example of how a process which will give very good results on a laboratory scale, will just fail to succeed when magnified to a size necessary for working on a commercial basis. Even the strongest supporters of the original Classen process do not now believe it to be a success as a money-making proposition.

The difficulties in the way to succes for this process are explained to be: (1) The length of time necessary to convert 1½ to 2 tons of wood, this requiring from four to six hours; (2) the quantity of acid required; (3) the prolonged action of so much acid and water in the rotating converter reduced the wood to a very fine powder and formed much sulphuric acid which, acting on the sugar and other substances, produced gums and caramels, and so made the complete extraction of the sugar from the residue very tedious and expensive. (4) The buckling and breaking of the lead lining of the converter which had to be repaired after every two or three operations, and proved a very great source of delay and expense.

The plant built in the United States, which is reported to have cost for building and working for a year about $250,000, has not been used for some time. Two chemical engineers, Malcolm F. Ewen and G. H. Tomlinson, who were associated with the Classen process, both in Germany and the United States, finding the original process unlikely to prove a commercial success, obtained substantial financial aid from a Chicago engineer, Mr. J. M. Ewen, and in 1904 began experimenting along new lines to overcome the difficulties which prevented the old process from being a success. The result of their researches and experiments has been to shorten the time of the hydrolysis in the converter from six hours to 40 or 45 minutes, to obtain the treated wood waste in a form which could be quickly and efficiently extracted, to devise a converter which is not in the least degree affected by the process, to reduce the quantity of acid employed, and to obtain a very uniform and large yield of fermentable sugar from wood waste.

This process, by the courtesy of the patentees, I was enabled to study in June, 1909, at Chicago Heights, about 20 miles from the city of Chicago. The plant was erected by the Wood Waste Products Company, now called the Standard Alcohol Company, which has control of the Ewen-Tomlinson patents. This experimental plant was composed of units of commercial capacity, and was set up in workshops in the grounds of a large machinery manufactory. It consisted of the same elements as those required for the older process, viz., the acid generating and recovery apparatus, a converter or digester, a battery of diffusion cells to extract the sugar, neutralizing and storage tanks, fermentation vats, and a distillery.

The converter in use at Chicago was a revolving cylinder, 12 feet by 8, of steel, lined with fire-brick, and set in cement of lead oxide and glycerin. It had a capacity of about two tons of shavings or three of sawdust. The wood waste, sawdust, shavings, or small chips, are dumped into the converter, which is completely filled, and is then closed air tight. Gaseous sulphur dioxide in measured quantity, only about 1 per cent by weight of the dry wood, is introduced through a perforated tube passing through the trunnions of the cylinder and thus through the center of the revolving mass of the sawdust. When the required quantity has been added the sulphur dioxide is turned off and live steam is introduced through the same tube till a pressure of about 100 pounds is reached. It takes from 10 to 15 minutes to get the contents of the digester heated up to the required temperature. The steam is then cut off and the digester revolves slowly for another 40 to 45 minutes, the temperature and pressure being kept constant, when the hydrolysis is complete. The steam, carrying with it the terpenes, the excess of sulphur dioxide, and some acetic acid, is then discharged into the absorption tank. The manhole is again opened and the coffee-colored chips and sawdust discharged into a V-shaped bin which supplies the conveyors going to the diffusion cells.

In the plant now being built for the Du Pont Powder Company at Georgetown, S. C., it is probable that there will be three or four converters, egg-shaped or spherical, and capable of taking four to five tons at one charge. These are to be so arranged that when the digestion in one is completed the steam and acid may be directly discharged into a second digester already filled with wood waste, thus saving time and expense in recovering the acid of each charge.

From the converter the treated wood is conveyed to the extraction battery, where it is rapidly and effectively exhausted by hot water, the acid liquid neutralized with slaked lime and carbonate, allowed to settle in the settling tank, and then pumped to the distillery, fermented and distilled.

In the tests that I made of the plant two charges of the converter were used. The first contained 3,623 pounds of shavings from Chicago mills, air dry and almost entirely pine. This carried 18.61 per cent of moisture, making the dry wood equivalent to 2,948.8 pounds. The second charge consisted of 2,992 pounds of shavings and 2,105 pounds of wet hardwood sawdust, consisting chiefly of oak, but with some pine. The total weight of the second charge was 5,097 pounds, with a dry wood equivalent to 3,058 pounds. This second charge was made with a view of testing the effect of the process on sawdust carrying a very high percentage of moisture. The sawdust gave on analysis 70.4 per cent moisture.

The product of the action of steam and sulphur dioxide on the first charge of shavings was a friable brown product resembling tan bark or coffee, with a fragrant aromatic odor and strongly acid. Analysis of this gave:

	Per cent.
Moisture	32.23
Total reducing sugars	13.70
Calculated to dry basis	20.20
Total acidity (as sulphuric acid, SO_3)	1.23
Sulphuric acid (SO_3)	0.418
Reducing sugars, fermented	10.70
Unfermented sugars, xylose, etc.	3.00

* Read before the Society of Chemical Industry, and published in its journal.

† Tenders have been offered to deliver, two hundred yards away, 200 tons of sawdust, etc., per day at twenty-five cents per ton.

The wood waste in the second charge after treatment resembled the heated shavings, but was finer and had a powerful aromatic odor and gave the following results:

	Per cent.
Moisture	34.63
Total reducing sugars	14.28
Calculated to dry basis	24.18
Total acidity	1.12
Sulphuric acid	0.353
Reducing sugars, fermented	10.97
Non-fermented matter, xylose, etc	3.21

The total weight of waste wood in the form of sawdust and shavings in these two charges was 8,760 pounds, or calculated to a dry basis, 6,007.1 pounds.

The treated wood was then exhausted with hot water in the extraction battery. The liquid containing the sugar from these two charges was collected in one storage tank and occupied a volume of 2,984 gallons, or 26,150 pounds in weight. The mingled liquors contained 5.6 per cent of reducing sugars calculated to dextrose.

The total acidity was 0.64 per cent calculated to sulphuric acid. Of this 0.21 per cent was sulphuric acid and the balance was composed of acetic acid, a little sulphurous acid, and aromatic compounds of the type of pyrogallol. The presence of the polyphenols and tannin bodies was most obvious. On neutralizing this solution with lime and calcium carbonate it blackened rapidly, and when ready for fermentation had an inky color due to the oxidation of the aromatic salts. The liquid also contained a considerable amount of furfurol. As there is little or no nitrogenous material suitable for yeast food in the liquor it does not ferment well alone, hence before adding the yeast about half a bushel of malt sprouts was added to a vat of 3,000 gallons as food for the yeast.

In this experimental plant various forms of yeast have been tried. The problem as to which particular breed of yeast will give the best results was, in June last, still unsolved. The yeast used in my experiment was brewers' yeast from a neighboring lager beer brewery, which was found to give constant and regular fermentations, but not more than 75 or 80 per cent of the theoretical yield of alcohol was obtained. The fermentation occupied about three days, when the liquid was handed over to the gager and distiller, who was an employee of the United States Government, and placed in charge of the distillery. From the 2,984 gallons of fermented fluid, corresponding to 6,007.1 pounds of dry wood the gager reported 115.92 gallons of proof spirit or 61.06 gallons of 95 per cent alcohol.

This will be seen to be equivalent to 20.55 gallons per ton of wood waste calculated to a dry basis, or 14.14 gallons per ton of wood waste, including the wet sawdust, which contained over 70 per cent of moisture. This alcohol when rectified to 94 per cent is of a potable spirit, crystal white, and carries no trace of odor or flavor of wood. It contains no trace of methyl alcohol or of the higher alcohols such as fusel oil, but gives the reaction for traces of furfurol and aldehyde.

At present there has been little or nothing done toward utilizing or indeed determining the quantity and value of the by-products resulting from the manufacture of ethyl alcohol by this process. The Standard Alcohol Company has contented itself with manufacturing a very cheap and pure ethyl alcohol and has left the working out of the by-products to the future.

The wood waste left behind after complete extraction is a friable cellulose and represents about 65 per cent of the original wood, of which only about one-third is rendered soluble and extracted by the process. This material, according to the present plan, is to be squeezed between rollers, dried partly by waste heat from the boilers and used as fuel. Turpentine and acetic acid are found in the absorption tanks after blowing in the steam from the converter and will no doubt be recovered.

In France there is in operation another process for the manufacture of ethyl alcohol from wood waste. I know nothing of this process beyond an account of it which appeared in the General Electric Review of September, 1909, by G. U. Borde. The claims for this process are interesting and extraordinary. Finding the Classen process unworkable on a commercial scale, the company that controlled those patents for France is reported to have so modified the process as to largely increase the value of the by-products, chiefly the acetic acid and the solid tailings, and can still produce about 20 gallons of alcohol per ton. The raw material is treated in a Classen converter with a solution of sulphurous acid at a pressure of 100 pounds. Neither the time required—a most important item—nor the form of the converter, nor yet the quantity of acid used, are stated in the report. From the profound change effected in the character of the wood, however, the process must be greatly prolonged and the sulphuric acid formed given ample opportunity to attack the cellulose. The digested mass is allowed to partly cool in the digester when it is found to have shrunken about 25 per cent. The sulphurous acid is recovered and the material from the digester passed over to a separator in which the acetic acid is recovered by vaporizing it with steam. The whole mass, without any attempt at separating the sugar, is then neutralized, made into a mash, which is fermented and distilled in the same way as an ordinary grain mash is handled in a whisky distillery.

The tailings from the still are compressed and dried as in the previous process by waste gases from the boilers. This material is claimed to be useful as a stock food, or can be briquetted or mixed with magnesia to form artificial stone of value. In an experiment conducted by the writer I am quoting, he obtained from 3,200 pounds of refuse wood, 21½ gallons of 94 per cent alcohol, 76 pounds of acetic acid and 1,800 pounds of stock food. The value of this he estimates as follows:

Alcohol at 40 cents per gallon	$8.60
Acetic acid at 6 cents per pound	4.56
Stock food at $23 per ton	17.25
	$30.41
Estimated cost of production	$7.00
Net profit	23.41
	$30.41

If this be a true estimate of the value of the products obtained from a ton and a half of sawdust, it is much more profitable than the process I have reported upon. The ethyl alcohol produced according to the above is of secondary importance both commercially and economically to the manufacture from sawdust of a foodstuff for stock of greater value than Indian corn. The description of the process does not convince one that the inherent difficulties of the Classen process have been removed. The exaggerated value placed upon the stock food is obvious. There is no reason, however, why a prolonged digestion of wood at a high temperature should not greatly increase the yield of acetic acid and might produce a substance from cellulose by the hydrolyzing effect of sulphuric acid which might have a food value, but necessarily a very low one after the extraction of the sugar. It is known that the partial hydrolysis of keratin (horn, hoof, hair, etc.) renders such substances digestible. If the process be carried so far as this, however, it seems very probable that the sulphuric acid formed would destroy much of the sugar and thus lower greatly the yield of alcohol.

In the Ewen-Tomlinson process which I have studied, it was found that the more rapidly the contents of the digester could be raised to the required temperature the shorter was the time required to produce the maximum yield of sugar. A gradual elevation of temperature, as occurs in the Classen process, induces secondary reactions and a lower yield of fermentable sugar. This rapid heating of the contents of the converter is only possible by the Ewen-Tomlinson method of introducing live steam into the interior of the mass by the perforated tube in the axis of the converter.

All will watch with interest the development of these two offsprings of the Classen process in America. A plant is being erected to use this French process at Hadlock, Wash., and another is proposed for some place in Ontario.

As to the cost of production of ethyl alcohol by the Ewen-Tomlinson process, a very close estimate has been made, based upon tenders and the experience of the patentees in the Classen plant. Broadly speaking, the cost is about the same as that required to produce alcohol from grain or any other starchy material. Outside the converter itself there is nothing used in the plant which is not quoted on the market and made for other purposes. Without going into details, a plant capable of handling 100 tons of dry sawdust in a ten-hour day, or working continuously, 200 tons per day, including buildings of a simple character and of cheap substantial construction, was estimated at $99,500. The daily cost of maintenance, including interest, depreciation, labor, and material, allowing 50 cents per ton for the sawdust or other wood waste, would amount to $217, i. e., $217 for 100 tons, or $2.17 for 20 gallons of alcohol, 90 per cent, or a net cost of 10.8 cents per gallon. No allowance is here made for fuel, save the cost of drying the unused portion of the sawdust. This estimate further is made on a plant not smaller than 100 tons.

When one considers the possible value of the by-products from a large plant, and the fact that quite 20 per cent of the available sugar was not fermented in the experiments made last June, it would appear that cheap industrial alcohol has at last arrived.* Ethyl alcohol from grain, 94 per cent, averages about 52 cents to the consumer without the government tax, and denatured alcohol from 45 to 60 cents. Alcohol made from refuse wood should not cost the consumer more than 20 to 25 cents.

Quite apart from its economic aspect, the manufacture of fermentable sugar from wood by this process is intensely interesting to the chemist. The process is essentially one of hydrolysis analogous to the conversion of starch to sugar by the amylolytic ferments. The celluloses are, like starch, polysaccharides of unknown constitution. They are generally represented as having the same percentage composition and empirical formulae, and just as we can represent the hydrolysis of starch to maltose and dextrose, so we can show how by the assimilation of water the cellulose can give rise to maltose and dextrose. It is assumed that it is the cellulose element in the wood which gives rise to the sugar.

I was much struck by the regular action of sulphurous acid upon the sawdust, a constant quantity, about 35 to 40 per cent of the wood, only being attacked. We know from the studies of numerous chemists, such as Hugo Müller, Sachs, Cross and Bevan, and others, that wood freed from adventitious constituents such as the tannins, coloring matters, resins, etc., is strikingly uniform in the composition of its fundamental tissues, notwithstanding the great variety in structural complexity, and this uniformity in composition is not confined to species, but is found to embrace all sorts and varieties of woody tissue. The average composition of wood from all sources may be said to be, water, 11 per cent; cellulose, 50 per cent; soluble in water, 3.5 per cent; non-cellulose, 35.5 per cent. Lignum vitæ and ebony are exceptions, being very low in cellulose and high in non-cellulose.

In the Classen patents and in one of the Ewen-Tomlinson patents it is the cellulose which is claimed to be converted into fermentable sugars. It seems more than a coincidence that the quantity of material hydrolyzed in the Ewen-Tomlinson process should be so constant and should correspond so closely to the proportion of non-cellulose found in woods. In all processes of hydrolysis the non-cellulose or lignose complex is the first to break down whether the hydrolysis occurs in an acid or an alkaline medium. There is every evidence that here the lignone complex is broken down. The presence of hydroxy-derivatives of benzene, of pentoses, acetic acid, and furfurol in quantity is obvious in the liquid extract of the treated wood. It seems probable that the lignone complex in woods is attached to a certain proportion of cell cellulose (hemi-cellulose) as well as to the oxy-cellulose and perhaps to the true fiber cellulose.

The material left after treatment consists of cellulose, which is found on being again submitted to steam and sulphur dioxide to yield but a trace of sugar. True fibrous cellulose (absorbent cotton) in another experiment remained unattacked. Its physical as well as its chemical properties were practically unchanged.

Under the conditions of the process a small quantity of sulphurous acid is employed for a short time only, and very little sulphuric acid is formed. It would seem that the acid acts here as a catalyzer inducing a rapid hydrolysis of the lignone complex and of a proportion of easily attacked cellulose. The oxy-cellulose for the most part and the true cellulose present are not seriously altered chemically. It would seem possible that, authorities to the contrary notwithstanding, the lignone complex is capable of yielding a certain amount of fermentable sugar. Should this, on further study, prove to be the case, it might be possible to treat pulp wood by this process as a preliminary to its conversion into pulp, and then by a second treatment to produce pulp fiber from the unattacked residue.

There is little doubt that in the original Classen process there was, owing to the larger proportion of acid and the prolonged action, a more profound action on the cellulose and the lignone complex, as well as probably a secondary action on the carbohydrates produced.

In a lumber producing country like Canada, any industry that can utilize waste wood and give it commercial value should receive encouragement. If this be the "revolutionary discovery," which the Department of Agriculture at Washington has pronounced it to be, it will add much to the wealth of nations. It will not only open up new fields for the use of industrial alcohol, but will liberate for use as food the million bushels of grain now used in the manufacture of ethyl alcohol, 9 per cent of which is used as a luxury in life and regarded by many as a distinct evil in the community.

Nature quotes an article in the Physikalische Zeitschrift by Dr. J. J. Kossonogow, of the University of Kiev, on the application of the ultramicroscope to the study of the phenomena of electrolysis. He finds that when an electrolyte is examined under the ultramicroscope, at the moment the current is switched on there appears in the field of view a number of bright points of light which travels toward the electrodes with velocities of the same order of magnitude as have been found for the ions. The path may be deviated by means of a magnet. When a point reaches an electrode it appears to attach itself and take a crystalline form. None of these appearances is observed in the case of a non-electrolyte, and the author considers he has proved beyond the possibility of doubt that the ultramicroscope provides a powerful means of studying directly the motions of the ions in electrolysis.

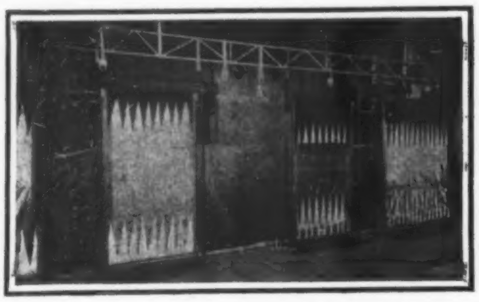
* The Standard Alcohol Company claims to be able to produce this alcohol at a cost of seven cents per gallon in a large plant. Its plant has been described in the Scientific American.

MODERN STAGE ILLUMINATION.

THE PASSING OF THE OLD FOOTLIGHT.

BY DR. A. NEUBURGER.

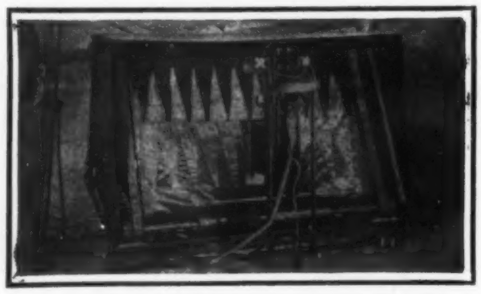
LIKE all other technical arts, the arrangement and illumination of the theatrical stage have been greatly developed and improved within the last decade. Formerly "wings" were used, which projected laterally into the scene, together with "soffits" hanging down from above. Both wings and soffits were illuminated



STRIPS OF COLORED CANVAS FOR PRODUCING DIFFUSED LIGHT OF VARIOUS HUES.

from the front and sometimes from the sides also. When the Meininger company made its celebrated tours, the value of a good stage arrangement and its influence upon the effect of the drama were made evident. Since that time continual endeavors have been made to improve the stage equipment. In the first place, the wings and soffits were abandoned and genuine closed rooms, with ceilings, were constructed; then the various objects, which had previously been represented by pictures painted on canvas, were constructed in plastic form, and in some of the new theaters even trees with realistic cylindrical trunks have been introduced. At the same time the illumination of the stage was improved. The electrical system was perfected, and the lamps were arranged to produce a great variety of effects. A great improvement was the introduction of the so-called regulator. This is an electrical switchboard controlled by one man, who is thus enabled to light and extinguish any lamp at will, to throw a flood of red, green, or white light over the stage, and to produce various effects of light and darkness. The operator, of course, must closely follow the action of the play and adapt the illumination to it.

In spite of all these improvements, the modern stage still fails to give a true representation of nature. The most striking difference between natural scenes and their reproduction on the stage is in the illumination. Almost everything we see in ordinary life appears in diffused sunlight. The rays of the sun are reflected, not only by clouds, but by the earth and various objects upon its surface, such as trees, house walls, etc. In this manner is produced an intricate mixture of reflected rays, or a diffused illumination, which exerts a peculiar effect upon the eye. This effect cannot be correctly reproduced by the current method of stage illumination in which numerous incandescent lamps throw their rays directly upon all objects. The difference was not so marked when painted scenery was used exclusively; but since the introduction of solid objects, very unnatural effects are produced by the present system of illumination. This is particularly striking when an attempt is made



PORTABLE APPARATUS FOR DIFFUSED ILLUMINATION.

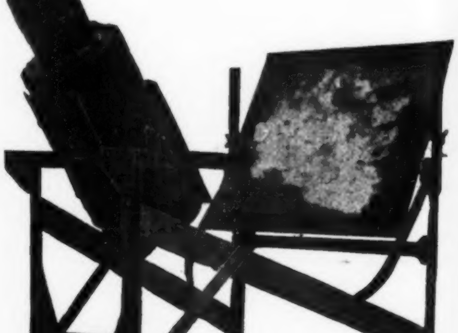
to imitate the intense diffused light produced by the sun shining through clouds. The great difference between natural illumination and stage illumination was first fully appreciated by the artist Mariano Fortuny, of Venice, who after a long course of experiments, carried on with the assistance of the General Electric

FRAME OF STAGE SKY SEEN FROM BEHIND.

Company of Berlin, has invented a new process of stage illumination, which closely imitates the conditions of nature and presents all objects in diffused light.

Arc lamps are used exclusively, as their light corresponds in composition most closely with sunlight. The lamps, however, do not shine directly upon the stage, but their light is reflected by surfaces of cloth and is thus diffused. In order to produce the various tones observed in nature, the reflecting surfaces are composed of a number of strips, some of which serve for the production of color and others for the modification of the light by an admixture of black or white. Not every gradation of tint observed in nature can be reproduced by these means, however, and therefore they are reinforced by the interposition of colored glasses between the lamp and the reflecting surfaces. This device is used, in particular, in producing the colors of sunset and sunrise, storms, etc. In order to obtain the closest possible imitation of nature, it is necessary that the person who controls the illumination shall be able to observe the effects which he produces. This is not the case in the employment of the old regulator, which was placed behind the scenes. The operator could, at best, see only part of the stage and could not form a correct judgment of the appearance which even that part presented to the spectators in front. In the Fortuny system, the apparatus is so arranged that it can be controlled from the rear of the auditorium by means of simple and inconspicuous switches. Hence the operator can follow the effect and assure himself that all is going well.

But even these devices cannot in all cases assure a correct reproduction of natural conditions. The "vault of Heaven" is not a mere poetical expression, but correctly describes the appearance which the sky presents to the eye, and this vault has much to do with the illumination of objects on the earth's sur-



APPARATUS FOR PRODUCING CLOUD EFFECTS.

face. So Fortuny introduced a vaulted sky into his system. The imitation may be rigid, collapsible, or even portable. One of the accompanying illustrations shows the light frame of the vault, seen from behind. The front or concave side of the frame is covered with dull white cloth, upon which the light, already diffused by the colored, black and white reflecting surfaces, is thrown. Hence the stage is illuminated by light which has been reflected twice and very natural effects are produced, including aerial perspective, which cannot be obtained by the current system of illumination, in which the painted sky is as opaque and glaring as the rest of the scenery. Clouds are represented by reflecting the rays of the lamps directly upon the vault by mirrors, and interposing transparencies of clouds, which may be moved, if desired, in the path of the rays. In this way the effect of motionless or fleeting clouds, delicate and fleecy or massive and opaque, can be imitated very accurately, especially as the vault of the sky behind them appears in its natural colors.

After this general description of the Fortuny system, we will mention a few of its most interesting technical details. One of the illustrations shows the reflecting surfaces, composed of strips of various colors, which can be moved by chains passing over rollers, so as to bring any desired portion into action. This operation can be effected slowly or rapidly, as desired. Another illustration shows a portable apparatus, in which the lamp is placed close in front of the canvas strips. In another picture we see the apparatus for the production of cloud effects, consisting of an arc lamp and a mirror bearing a picture of a cloud. The general effect produced by the Fortuny system of illumination is well illustrated by the picture of a stage scene, photographed by means of the illumination used in the performance. When we compare this with the coarse effects, harsh contrasts

A STAGE SCENE PHOTOGRAPHED BY THE ILLUMINATION PRODUCED BY THE FORTUNY SYSTEM.

and unnatural shadows of ordinary stage scenes the superiority of the Fortuny system becomes evident. Not only are the defects just mentioned eliminated, but the seams in the canvas, the sharp edges, folds, projections, and other imperfections of ordinary scenery no longer remain to destroy the illusion.

The method of attaching the vaulted sky to its frame is very interesting. It is necessary for the canvas to present a smooth concave surface, which never could be produced by nailing or similar methods. The problem was solved by using two quadrantal gores of air-tight canvas, one of which is attached closely to the frame, while the other, which is turned toward the spectators, hangs loosely from the top of the frame. The two gores are attached together by their edges, so as to form a perfectly air-tight bag. By means of a small air pump the air is withdrawn from this bag and the front surface of canvas is consequently pressed tightly against the other and the frame behind it, without showing a fold or wrinkle. The frame can be raised and lowered in sections, like a phaeton top, and can be raised at the back, so as to leave the stage beneath it entirely clear for the setting of the scene. When all is ready the frame is dropped at the back, and a few seconds' operation of the air pump gives the canvas the required smoothness. The Fortuny system of illumination is already in experimental operation at Kroll's Opera House in Berlin, where it has met with remarkable success.—Fuer Alle Welt.

AN AUTOMATIC STAMP VENDING MACHINE.

A NEW FRENCH DEVICE.

BY LUCIEN FOURNIER.

In France the introduction of automatic stamp vending machines was impracticable before the reduction of the rate of postage for ordinary letters to ten centimes. The construction of a machine requiring for its operation the insertion of two coins of different dimensions was a problem too difficult to attract inventors, especially in view of the moral certainty that such a machine would never become popular.

Soon after the reduction in the rate of postage, the Abel Automatic Machine Company submitted to the government several stamp-vending machines, which were installed in the Paris post office and have worked with perfect regularity. It is to be hoped that this system will be adopted by the postal service, to the great convenience of the public, for the machine can be set up almost anywhere, and can be arranged to accommodate a letter box under the mechanism. The construction of the apparatus is sufficiently curious and interesting to merit a detailed description of its two essential organs, the coin tester and the apparatus for delivering stamps.

The Abel coin tester makes use of the magnetic principle which is employed in the Fodor letter-registering machine (described in the Scientific American, December 4th, 1909). The members of the French Académie des Sciences who praised so highly the ingenuity of the Fodor machine appear to have been ignorant of the fact that the same principle has long been utilized in similar machines in other countries. The Abel coin tester is shown in Fig. 3. The coin is inserted, in a vertical position, into the mouth of an inclined chute *T*, of rectangular cross section, which is just high and wide enough to allow the ten centime piece to pass. The coin rolls down the chute, strikes a steel cylinder and rebounds with a force just sufficient to cause it to enter a second chute, which conducts it to the cash box. In its course it strikes a lever, which unlocks the mechanism for the delivery of stamps. If a piece of iron or steel is substituted for the coin it is arrested in the first chute by the attraction of the magnet *AA*, and is expelled from the machine by pressing a button placed beside the coin slot. This button moves the lever *L*, which, acting on the crank pin *D*, raises one side of the chute, which is hinged at the top to the other and fixed side. At the same time the frame *C*, which surrounds the poles of the magnet, moves outward and detaches the piece, which falls into a chute that carries it out of the machine. The movable side of the chute *T* is cut away to so great an extent that a non-magnetic substitute

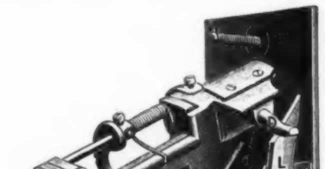


Fig. 3.—PART OF THE COIN TESTER.

of a diameter even slightly less than that of the ten-centime piece, falls of itself out of the chute and follows the subsequent course of the iron token. A piece which is too thin becomes lodged in a groove at the bottom of the chute and is expelled by pressing the button. After passing all of these tests the coin is subjected to the test of elasticity by its impact upon the steel cylinder. A piece of lead of the exact dimensions of the ten-centime piece, for example, would not rebound sufficiently to gain the chute leading to the releasing lever and the cash box, while a substitute slightly more elastic than the ten-centime would rebound with sufficient force to carry it back through the entire length of the chute *T* and to expel it from the coin slot. The machine now in use can be operated by foreign coins of the dimensions and composition of the French ten-centime piece, although the coin, before dropping into the cash box, can be inspected through the perforated plate shown at *D* (Fig. 2). The manufacturers now claim to have invented a device which will reject foreign coins.

The mechanism by which the stamps are delivered is shown in Fig. 4. A strip of 500 stamps is drawn from the reel *T* by two pairs of milled wheels, *M* and *N*, which are connected by gearing with the driving shaft *A*. The strip of stamps is pressed against the milled wheels by corresponding free wheels carried by the hinged front *P*, which is shown open in the illustration, and its motion is guided by the smooth rollers *C*, between the upper wheels *M*, and by a smooth vertical rail on each side of the wheels. The circumference of the milled wheels is greater than the length of a stamp, but a sector is removed, leaving an arc of the exact length of a stamp. The movement of the strip is regulated by the two V-shaped pieces *LG*, which are pivoted at *O*. The inner branches of these pieces carry pins which enter the perforations between the stamps and which bring the strip to rest with the line of perforations exactly in front of the slit *E*. The rods *T*, above and below this slit, then advance and press the two stamps firmly against the front piece *P* and, a moment later, a very sharp steel blade of the exact width of the stamps, emerges from the slit and cuts through the line of perforations, detaching the stamp at the end of the strip. The knife is driven forward very quickly by a rack and pinion and is brought back by a spring. The detached stamp glides down into the receptacle *S* (Fig. 1). The purchaser opens the door of this receptacle and removes the stamp.

If the strip of stamps is exhausted or torn, the coin tester opens and returns the coin. In foreign machines the nearest post office is automatically informed by an electrical signal of the stoppage of the apparatus from this or any other cause. The motive power of the Abel machine is furnished by a simple clockwork. The public prefers the automatic method of purchasing stamps, because it is more expeditious than the old way.—La Nature.

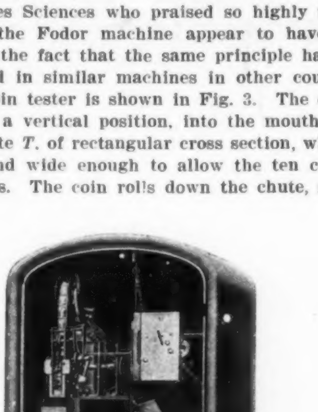


Fig. 1.—THE ABEL STAMP VENDING MACHINE OPENED.

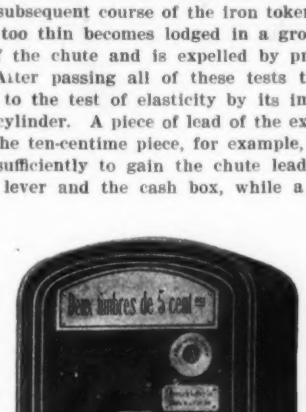


Fig. 2.—THE ABEL STAMP VENDING MACHINE CLOSED.

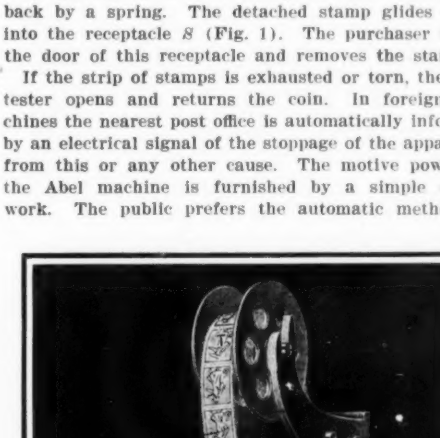


Fig. 4.—THE MECHANISM FOR DELIVERING STAMPS.

Britannia Metal Coating for Brass Articles (according to C. Puscher).—Solution: Forty-five parts powdered tartar and 4 parts tartar emetic dissolved in 1,000 parts of hot water, add 50 parts of hydrochloric acid, 125 parts powdered tin and 30 parts of powdered antimony. Heat all in a well-glazed vessel to boiling and dip the article in; after 15 to 30 minutes the coating is completed.

THE DEVELOPMENT OF POWER SYSTEMS.*

A CONSIDERATION OF PRIME MOVERS.

BY CHARLES EDWARD LUCKE, PROFESSOR OF MECHANICAL ENGINEERING IN COLUMBIA UNIVERSITY.

In the story of the development of machinery, the part played by rods, shafts, cylinders and other elements of the mechanism, is subordinate to the conceptions of physical processes which each arrangement of parts is devised to carry out. It is more important to know just how steam should be treated in order to obtain the most work than to be able to make a steam engine that will run; it is more important to know how a combustible gas mixed with air should be treated to give an explosion producing the highest possible pressure, than to be capable of making a chamber strong enough to withstand the effects of the explosion. Each process as it is conceived adds a fact to man's understanding of nature and in turn contributes to the discovery of the next.

Air and water in motion being capable of moving wheels with paddles naturally leads a student to inquire how fluids may be put in motion; a question which once conceived almost instantly answers itself—by allowing them to escape from high-pressure chambers. The next logical inquiry is, how may fluids be prepared so as to be under high pressure in chambers from which they may escape? This leads to the discovery that water may be boiled in closed vessels and that explosions of powder or gaseous fuels may be caused, resulting in the desired high pressure, or more simply, water may be led in pipes from the upper level of a falls to the lower, and at once the three characteristic systems of power generation are understood.

An almost infinite number of combinations of mechanism parts can be found to carry out each process. The processes are fundamental, the mechanisms, incidental. It must not be assumed, however, that the parts may have infinite variety of form or that they may be made of any material, for there are limitations which cannot be ignored. The elements must have such simple form that they may be easily made by the workmen. Both the form and material of each part must be suitable in strength, stiffness, flexibility and wearing qualities. The whole machine must not be too costly to produce nor to keep in repair and it must not require too much skill on the part of the operator. The problem of power-machinery development is divisible into several parts:

First. What processes must be carried out to produce motion against resistance?

Second. What combinations of simply formed parts can be made to carry out the process?

These two parts when worked out will result in some kind of an engine; but it may not be a good engine, for it may use up too much natural energy for the work it does; some part may break or wear too fast, another may have a form that no workman can make, or use up too much material or time in the making; in short, while the engine may work, it may do its work at too great a cost, in coal or water, in attendance or in investment. There must, therefore, be added other elements to the problem.

Third. How many ways are there of making each part, and which is cheapest? What other form of part might be devised that would be cheaper? What cheaper material is available which would be equally suitable?

Fourth. How sensitive to care are all these parts when in operation and how much attendance and repair work will be required to keep the machine in good operating condition?

Fifth. How big must the important parts or the whole machine be to utilize all the energy available or to produce the desired amount of power?

Sixth. How much force must each part of the mechanism sustain and how large must it be when made of suitable material so as not to break?

Seventh. How much effective work can the machine do for each unit of energy supplied?

In the early days of power generation all these elements were not recognized. They were developed and studied about in the order named; a fairly satisfactory solution of the first parts pointed out the existence of those that followed and the necessity of studying them. The solution of a new question reacted on an older one so that new solutions of the older question appeared which could not be conceived before. Systematic study of engineering problems has been receiving attention for about a century and a half, but has been divided into periods as the study advanced to the higher stages. For example, it was not until about 1860 that the seventh element of the problem was successfully treated for those power systems depending on the heat of fuel as the source of energy. Although successful and commercially valuable steam engines had been continuously produced for a hundred years, no one was able to calculate exactly how much of the heat in the steam might be converted into work by a mechanism ideally perfect, so that the goodness or badness of a given engine could not be judged by scientific standards, but only in a comparative way. One machine might produce a horse-power with less coal than another, but no one could state positively why, which, of course, is the first step in rational improvement of economy. But the minimum possibilities of coal consumption for a given system could not be calculated, hence, the comparative value of competing systems could not be judged. This sort of calculation is now an everyday thing which every engineer is capable of carrying out and is the basis of all modern designing and improvement. The fact that it took over a hundred years after building useful engines to arrive at a scientific conception of the fundamental processes which were being more or less imperfectly executed in machines designed largely by rule of thumb, is doubly significant of the high order of mental development necessary for it when it is realized that the first and second elements of the problem were understood to a degree sufficient to enable men to produce working models some two thousand years before.

The period of systematic and scientific power development is coincident with true progress in the most basic of the several branches of natural philosophy, of chemistry, physics, mechanics, thermodynamics and the theory of elasticity of materials; and there is no doubt that the steam engine, which was built by mechanics before basic laws were well understood, attracted the attention of philosophers who, in attempting to explain what took place in it, created a related body of principles by which future development was guided. Those men who became familiar with natural science and also with shop methods of making machinery and who brought their knowledge to bear on the problem of the production of machinery for specified conditions, combining the special knowledge of the scientist with that of the shop mechanic, were the first mechanical engineers; and the profession of mechanical engineering which is the term now applied to this sort of business was created out of efforts to improve power systems so as to make them more efficient and better adapted to various classes of service.

Nothing is more interesting than the detailed history of power-system ideas, mechanism and the production of both the machinery and the power itself, studied along with the parallel development of the natural sciences. But this is beyond the scope of these lectures in which no more than the merest outline can be attempted, just sufficient to permit of a little understanding of modern machinery.

As has been already said, one of the earliest understood ideas applied to power generation is that water in motion may, by striking paddles on wheels, move them, and itself lose some of its motion, or that the energy of motion can be communicated from one body to another. One of the earliest kinds of wheels was hung by its shaft, which was just a log of wood, over the surface of a fast-moving stream at such a height as would allow the paddles to dip into the water. The idea involved, old as it is, is one of the most modern inasmuch as it is basic to the largest modern water and steam turbines. It must not be understood that the basic idea consists in the dipping of paddles into a brook; this is a mere incident, a convenient way of making use of the real, fundamental principle that the energy of moving fluids can be imparted to wheels by bringing the fluid to rest in a suitable way.

In most of the modern turbines, which is the name applied to the highly developed forms of wheels designed to rob moving fluids like steam and water of their energy of motion, there are involved many other principles, some of which are very old and some of recent conception. One of these, easy to understand, is concerned with the way in which water may conveniently be set in motion. Water led from an elevated tank or pond by pipe to a lower level exerts a pressure tending to burst the pipe which is more powerful the greater the drop, and the greater the pressure is the greater the velocity of the water flowing from the nozzle. Similarly, water, steam, air or any other fluid, existing in a chamber under pressure, will escape from that chamber through a nozzle in a jet which will have a velocity determined by the pressure. The quantity of fluid that can escape, as well as the energy of the jet, will depend on the size of the hole and velocity of the jet. It has always been found more convenient because of the concentration of energy that results, to devise means of getting the fluid under pressure, and then allowing it to escape in order to give it motion instead of depending on fluids naturally in motion. Jets of fluid may be allowed to play on vanes or paddles in a great variety of ways, giving different types of motors all known by the class name of impulse wheels. Some have one nozzle and others many; the arrangement and form of vanes vary greatly.

It required many years of experiment, calculation and comparison to discover just what curvature and angle should be given to vanes and nozzles to secure high efficiency, for while almost any combination will run there is only one best design and the determination of that best design is the principal problem of the engineer to-day. To such perfection has this work been carried that it is now possible to predict within 1 or 2 per cent. how much of the fluid energy a turbine, yet unbuilt, will be capable of transforming into useful work. A proper relation between the speed of the vanes, that of the steam jet and the angles and curvature will allow the steam to leave with the lowest practical velocity, most of its original energy of motion having been imparted to the wheel, and these things can now be determined with precision. When the water issues in a fast-moving jet from a nozzle, the nozzle is pushed backward, just as a gun recoils as its projectile moves out, and this principle of reaction is used in both water and steam turbines, either alone or associated with the impulse action. To all wheels in which the reaction of the jet rather than the impulse of its striking the vanes exerts the driving force the class name of reaction wheels is applied.

The antiquity of the reaction and impulse principles is shown by the records in which it is said that one Hero, 200 years B. C., made a steam reaction turbine, in which a fantastic water vessel was heated by a fire, making steam which, flowing up two vertical standards, hollow like pipes, entered a ball arranged to rotate on the ends of the standards. From the ball the steam escaped by nozzles tangentially, causing the ball to spin, to the mystification of the mass of the people, who believed that some spirit from the other world had been brought under command. A later, but nevertheless old device, dating from 1629 and credited to Branca, an Italian, is a pure impulse steam turbine, coupled by tooth gearing to a shaft with lumps on it arranged to lift pestles for crushing corn or ore.

The simplest, oldest and at once the most modern ideas for power generation are then:

First. A moving fluid properly directed may move wheels against resistance when it strikes vanes suitably formed and arranged.

Second. A fluid under pressure may acquire motion simply by escaping.

Third. Jets of fluid escaping from nozzles or suitably formed passages in wheels may by the reaction of escape alone turn those wheels.

To these principles, minute and painstaking investigation guided by progress, which no doubt assisted in stimulating as well, in mathematics, mechanics, physics and chemistry, there has been added a vast body of engineering principles by means of which true design can be carried out, and turbines built of predicted efficiency and of proper strength in all parts.

It is a most significant fact that although Hero produced a rotative steam engine, that worked, in 200 B. C., nearly two thousand years elapsed before the first commercial rotative steam engine was produced by Watt about 1780, and that after him the progress of about seventy years in power-steam development resulted in advances which entirely eclipsed all the progress made since Hero's time. There are good reasons for this, and the key is to be found, first, in the lack of demand; and second, in the lack of information to enable makers of machinery to meet the demand when it came. Practically all the power machinery produced before the time of Watt in 1780, except special devices adapted to pump water only, was more the result of accident than of logical reasoning from desired results to means by which they might be attained. Even after Watt, much that was done was prompted by a desire to do something different, a groping after something by trying everything. There was no conviction based on proof or established principles that the means were right or best. This is

* Abstract of second Hewitt lecture, delivered at Cooper Union, New York city.

pure invention without which, it is true, little progress is possible. A conception that the new thing must produce the desired result in a truly better way or produce a new result superior to the old with no more wasteful means, becomes possible only when there is available a body of facts and principles related to each other and so constituting a science by means of which existing machinery can be analyzed to reveal all faults and their causes and the performance of new machinery yet unbuilt can be predicted with reasonable certainty. This is true design, without which invention alone may result in nothing more than interesting toys. But when combined with invention, design gives the engineer command over nature. The basis of engineering design is knowledge of facts and principles, so it is easy to understand why in the early days of engine building no true design was possible, for the machine and its operation themselves supply the means for collecting the necessary facts, and mental capacity, however well trained, cannot find the relation between the facts until the facts themselves are found by tests of the machinery. Once discovered and classified, these relations constitute a body of principles having the force and dignity of laws of nature, the discoveries and application of which to the uses of men constitute the profession of engineering.

FAST AND FUGITIVE DYES.*

SOMETHING ABOUT THEIR CHEMISTRY.

BY PROF. OTTO N. WITT.

IN order to make a thorough and methodical investigation of the behavior of colored substances, i. e., substances which exert a selective absorption upon light, we must first ascertain how those bodies act which do not exert an appreciably selective action upon the various rays of white light. Such bodies may absorb all the light which falls upon them, in which case we call them black; or reflect it all, in which case they are white; or allow it all to pass through them, in which case they are transparent. None of the classes thus defined is represented exactly by any earthly substance. Bodies which absorb part of the incident light and reflect or transmit the remainder present the various shades of gray, but are commonly regarded as gray only when a rather large proportion of the incident light is absorbed. Many substances which are really gray, according to the definition given above, are regarded as white, and almost all of the objects which we call black are really gray. Absolute blackness, in the strict sense of the word, can be produced only by viewing the so-called black bodies in the faintest possible light, as for instance when we look through a small hole into the interior of a box lined with black velvet. If we place beside this hole an ordinary black body, we see how far it is from being black in reality. The eye is very sensitive to differences in quality, but for quantitative measurement it is a very unreliable instrument. Its estimation of the intensity of light depends chiefly upon contrast, and when the contrast is great, none of our organs of sense is more easily deceived than the eye. Upon this fact depend many remarkable phenomena and many artistic effects.

We live therefore in a gray world, although this gray is diversified and beautified by many colors, for tinted objects are much more common than pure gray or black-and-white objects. Let us see what becomes of the light absorbed by these gray objects. Light as a form of energy is so nearly related to heat that all the laws of heat apply also to light. Hence there can be no doubt that any body can be charged with light as well as with heat. The quantity of heat absorbed by the body can be measured, and thus is obtained the idea of heat capacity, or specific heat. For the measurement of the energy of the light absorbed by bodies, on the other hand, no method has yet been devised. Hence the conception of specific light or light capacity has not been formed, but that the light which is absorbed by a body remains, in a sense, attached to it, is a necessary conclusion from the fact that the absorbed light can be extracted from the body, not necessarily as light, but as energy in some form.

The simplest case is that in which the light which has apparently been destroyed by absorption subsequently reappears as light. This occurs with numerous substances which are known as phosphorescent, especially with the sulphides of calcium, barium, strontium, zinc, and some other metals which, after exposure to bright sunlight or electric light, retain the energy which they have absorbed and give it out again as a steady luminous glow during many hours. The phosphorescent light which they emit is not always white. It is usually colored, and this fact indicates that the white light which has been absorbed is not emitted again entirely but only in part, rays of certain wave length having been retained and converted into some other form of energy.

Phosphorescence, however, is an exceptional phenomenon. Most of the substances that absorb light, and consequently all of those substances which we call black or gray, never emit the absorbed light again as light. What, then, becomes of the absorbed light? Every person can easily give the answer to this question; in fact he does give it daily by his unconscious actions. In the bright sunlight of summer, on tropical journeys, in active exercise in the open air, we put on white or light-colored garments, which reflect light, but in the gloomy winter we wear dark-colored clothing which absorbs light. Why do we do this? Because the light absorbed by our clothing is converted into heat and felt as such. We make tents and parasols of white fabrics, which reflect the sunlight instead of absorbing it and converting it into heat. Indians and Eskimos, however, use dark-colored tents, for the very reason that they are warmer. In Norway, Sweden, and Russia, houses are painted in dark colors, so that they are kept warmer by the absorbed sunlight, but in southern countries houses are painted white in order to make them as cool as possible. This is the most general action which bodies exert upon the light which they absorb; they convert it into heat which they give out by radiation and conduction. The energy is not lost, but its wave length is changed. It is degraded, as the energy of an alternating electric current is degraded in a "step-down" transformer. An electrical transformer consists of an iron core surrounded by two coils of wire. When an alternating current is passed through one of these coils a great part of the energy of the current is absorbed, and is reproduced in the form of an alternating current which is induced in the other coil. According to the length and diameter of the wire in the two coils, the electromotive force, or voltage, of the induced current may be equal to, or greater, or less than that of the primary current. A body that absorbs light acts like a transformer; it absorbs the primary current of light, consisting of energy of certain wave lengths, and it emits induced energy of different wave lengths. If the wave length of the emitted light is greater than that of the light absorbed, the energy produced by induction consists of radiant heat. If the wave lengths of the absorbed and emitted energies are nearly equal, the body emits light in addition to heat, and is called phosphorescent. A third case is conceivable, in which the wave length of the energy absorbed is shortened, as in a "step-up" transformer.

Let us now return to the colored bodies which exert a selective absorption upon light. It is obvious that this selective absorption is only a special case of the phenomenon described above; but because we are here dealing with luminous energy of perfectly definite wave lengths, we can follow the process of transformation much more accurately, and in particular we can learn something of the hypothetical third case just mentioned. The commonest case is that in which the light which is selectively absorbed undergoes an increase in wave length, or is "stepped down" and is converted into dark radiant heat. As this heat can escape freely and continuously, the process can continue indefinitely. The active body, the dyestuff, acts only as a transformer, without undergoing any change in itself. This is the characteristic of permanent dyes.

But the transformation is not necessarily carried so far. Some substances absorb only the rays of shortest wave length: the green, blue, violet, and ultra-violet rays. The wave length of the energy thus absorbed is increased, and the energy is emitted in the form of light of somewhat greater wave length. Substances which act in this way are called fluorescent.

The class of dyestuffs, however, includes, in all probability, substances which modify the absorbed luminous energy in the opposite direction, converting it into rays of shorter wave length, which manifest their presence by their chemical effects. I grant that this case offers the greatest difficulties in regard to quantitative investigation, for we know little or nothing of the nature and magnitude of the ether waves which are capable of being transferred to matter and of producing intramolecular chemical changes, but the energetic chemical action which we commonly observe in connection with blue, violet, and ultra-violet waves, suggests the inference that matter is affected only by vibrations of very short period. It seems also very probable that those dyestuffs which possess the power of causing chemical changes, with the aid of the light which they absorb, first diminish the wave length of that light. There is something fascinating in the idea of explaining in this manner the great chemical transformations wrought by chlorophyl, the green coloring matter of plants, which abosrbs only the red or long waves of the sunlight which falls upon it, and employs the absorbed energy in the production of starch from carbon dioxide.

There is, furthermore, a practical example to support the assumption of the possibility of such "step-up" transformation. This example is the well-known effect of the so-called color sensitizers upon the haloid salts of silver, especially silver bromide. This compound, when pure, absorbs only the blue, violet, and ultra-violet rays of the spectrum and is affected photographically, i. e., chemically, by them alone; but if it is mixed with one of the dyestuffs which act as sensitizers, it becomes sensitive to the action of the rays which are absorbed by this dyestuff. The dye erythrosin, for example, produces sensitiveness to green and yellow-green. I do not know how this phenomenon could be explained more easily and naturally than by saying that the erythrosin converts the green light which is absorbed into rays of shorter wave length, probably ultra-violet rays, which are able to affect the silver bromide. This peculiar action of erythrosin is by no means dependent upon its association with silver bromide, but is manifested also in other circumstances, the investigation of which would occupy too much space.

This example of erythrosin leads us naturally back to the consideration of fugitive dyestuffs. These are simply dyes which employ in chemical work the energy which they absorb. The effect in some cases is transmitted to other substances which are associated with the dyes, as in the case of chlorophyl; but when these substances are not present, to act as anvils for the hammer of the induced energy, the dyestuff itself becomes the anvil and is shattered by the waves which it emits.

An important support to the hypothesis concerning the mutual actions of light and dyestuffs which is here developed is given by a property which is characteristic of all fugitive dyes, for these dyes are not fugitive under all conditions. Every dyer knows that some dyes produce fast colors on some fabrics and fibers and not on others, and that the permanence of other dyes is largely dependent upon the nature of the mordant which is employed to fix the color in the fiber. Some mordants, the so-called oil mordants, for example, when used alone, destroy the permanence of otherwise fast dyes, and hence can be used only in connection with other mordants. Furthermore, the colors produced by fugitive dyes can be made permanent by impregnating the dyed fabrics with salts of copper, or other substances, upon which the chemical action of the dye can be exerted, so that the dye itself is protected from this action. In the Middle Ages, the Guild of Dyers was divided into two sections, the good dyers and the poor dyers. We see from the above considerations that a dyer belongs to one or the other of these divisions, according to his understanding of the peculiarities of his dyestuffs, which are not, unconditionally considered, either fast or fugitive.

I am fully aware that in this and the preceding article, I have made many assertions which are not to be found in the textbooks, and which, consequently, will give rise to head shakings, contradictions and calls to order. But all this does not trouble me. I had the same experience in 1875, when I published my views regarding the connection between the chemical constitution and the properties of dyestuffs, and in 1888, when I announced my theory of the process of dyeing. Both of these theories have since been accepted and have become the bases of further advances in knowledge.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

* This article should be read in connection with Prof. Witt's article in the last number of the SUPPLEMENT.

WOODEN MONUMENTS OF THE NORTHWEST COAST INDIANS.*

CURIOUS TOTEMS AND THEIR MEANING.

BY HARLAN I. SMITH.

On an expedition along the northwest coast of America, between Seattle and Skagway, Mr. Harlan I. Smith of the Department of Anthropology of the American Museum, New York, was able to resume during the past summer the archæological reconnoissance which he began on the Jesup North Pacific Expeditions of 1897-98-99, and continued on that of the American Museum in 1903. He carried this reconnoissance onward from the northern end of Vancouver Island, where work stopped on the previous expeditions, to Kluckwan, Alaska, some twenty-five miles above Haines on the Chilkat River; obtaining also photographs and many data regarding the ethnology of the region and securing specimens not already represented in the Museum collections. He was accompanied by Mr. Will S. Taylor, mural artist, who made color sketches of the Indians and their natural and artificial environments. These sketches, together with the photographs and the actual ancient costumes and other specimens available in the Museum, will form the basis upon which Mr. Taylor will build up mural decorations for the Hall of Northwest Coast Ethnology, to illustrate the home country, characteristic occupations and social customs of the seven great groups of northwest coast natives.

The scientific results of the trip are interesting because the archæology of the entire coast north of Vancouver Island as far as Mount McKinley has been unknown to the scientific world. In the Bella Coola valley about midway along the British Columbia coast Smith saw chipped implements, marking the farthest north of the art of chipping stone in British Columbia. Evidences were also found here of the relation of the early people to those of the interior. Although the Indians have given up much of their old life, he still found many purely native manufactures among them. Pictures bruised on the rocks by some of the ancient Indians were seen near Wrangel. The first stop of any length was at Victoria, a town perhaps more typically English than any other in North America. The Indians here have been little disturbed, so that even near the city both the southern Salish and the Nootka groups may be studied. Among the interesting photographs and sketches made here were one of an Indian making a dugout canoe from a cedar tree, and one of a Nootka man carving a totem pole.

From Victoria the expedition went by steamer to a small island near the northern end of Vancouver Isl-

* Abstracted from articles in the American Museum Journal, February 1910. 1. A visit to the Indian Tribes of the Northwest Coast, by Harlan I. Smith. 2. Results of an Art Trip to the Northwest Coast, by Will S. Taylor.

MORTUARY COLUMN, WRANGEL, ALASKA. THE BODIES ARE WITHIN TWO COVERED NICHES IN THE SHAFT.

PAGAN VILLAGE, BELLA COOLA, DESERTED, THE INHABITANTS BEING AWAY AT THE SALMON CANNERIES.

CHILCAT BLANKET (UNFINISHED) AND PATTERN BOARD, KLUCKWAN, ALASKA.

CHINOOK CANOE, NEAR VICTORIA. THE INDIAN IS DIGGING OUT THE INTERIOR WITH AN ADZ.
NATIVE CEMETERY, BELLA COOLA. WOODEN REPRESENTATIONS OF "COPPERS" AND CANOES INDICATIVE OF WEALTH AND HOSPITALITY OF THE DECEASED.

TREE-TOP BURIAL, SHOWING INDIAN GRAVES IN TREES, ALERT BAY.

WOODEN MONUMENTS OF THE NORTHWEST COAST INDIANS.

and, where at Alert Bay there is a tribe of the Kwakitul. In spite of the influence of several other races living and working in their midst the Indians of Alert Bay in many ways keep to their old methods of living. For instance, although there has been a missionary here for a long time he has not been able to stop burial in tree tops, as shown in the tree-grave illustration. The Indians must have practised this custom very recently, as some of the bodies were doubled up in common cheap trunks which can be bought only in the white man's store and are of a sort not made till a few years since. In the older graves the bodies were placed in boxes made of three pieces of wood split from red cedar. One of the pieces served as the bottom, another as the top, and the third was notched and bent around to form the ends and sides of the box. Where the edges of the boards met they were sewed together with spruce roots. Sometimes the boxes were painted, and occasionally both painted and carved with the characteristic animal pictures of the region.

Some of the Indians bury their dead in the Christian cemetery, but even then show remnants of old customs. Near one of the graves a fine bureau stood in the wind and rain. Perhaps it had been owned and highly regarded by the woman interred or had been something that she had longed for, and now that she was dead her relatives were showing the greatness of their grief by sacrificing a valuable piece of property to the elements. The Indians often erect beside the graves curious monuments such as wooden representations of "coppers," as shown in the engraving. These coppers are pieces of metal of distinctive shape and markings. They are of no great intrinsic value, but when bought and sold among the Indians they increase to almost fabulous worth. When a copper is transferred there is always a gathering and a feast. The Indians value a copper so highly that the white storekeeper takes the piece of metal as credit and advances groceries and drygoods to the Indians for perhaps a whole year until they are able to go to the cannery and earn money. On coming back from the canneries the Indians always redeem their copper securities and again use them, buying and selling them at enhanced values and with special ceremonials.

From Alert Bay the expedition moved northward to Rivers Inlet, where lives another tribe of the Kwakitul Indians, and there a photograph was secured of a perfect specimen of totem pole, reproduced herewith.

The expedition next went to Bella Coola, at the extreme eastern end of Burke Channel, about sixty miles inland beyond the usual course of steamers. There is an Indian village on each side of the river. The one to the north consists of Christianized Indians who have settled here, leaving the pagan Indians on the south side. The houses in the Christianized village are similar to those of the white people of the vicinity. Near the pagan village, seen in the engraving, dwell Mr. John Clayton and his family. He is the venerable Hudson's Bay man who keeps the store and is one of the richest and best known men living on the coast of British Columbia north of Vancouver. In the Christianized village are the church and the home of the missionary, the Rev. W. H. Gibson. Both Mr. Gibson and Mr. Clayton were instrumental in assisting the scientists to secure totem poles for the Museum.

The river at this place is fed from the snow peaks farther to the east and is icy cold. It is very swift and navigated only by long canoes dug out of single tree trunks. These canoes are spoon-shaped at each end and are entirely different from the ocean canoes of the coast. They are poled where the river is too swift for paddling. A stranger's best policy is to sit on the bottom of the canoe and leave its management to the Indian owner.

At Bella Coola they found an old man carving spoons out of alder wood and an old woman weaving strips of cedar bark into mats. Indians from the interior come to Bella Coola. They look different from those of the coast, are more active and angular. The costumes of both men and women are slightly different from those of the people of the coast. They wear moccasins, which are not used by the Bella Coola or their neighbors, who spend much of their time in the surf and on the beach.

The longest stay was made at Wrangel, in the country of the Tlingit Indians, where are large numbers of totem poles, carved grave posts and mortuary columns.

Kluckwan is a village of the Tlingit Indians on the old Dalton trail to the Klondyke. Here they saw the Tlingit women making Chilcat blankets. This blanket, as is well known, is one of the most remarkable kinds of weaving done in North America. It is made from cedar bark and mountain goat wool and decorated with woven designs characteristic of the region. In very ancient times the designs were of a geometric character, similar to those of the Tlingit baskets, but the blankets which are seen to-day bear the animal motives common on the carved wooden boxes of these people.

From Kluckwan, Mr. Smith returned to the Museum, while Mr. Taylor continued his color studies for two distinct series of pictures in mural decorations planned to show Indian industries and Indian

TOTEM POLE OF RIVERS INLET INDIANS.

WOODEN MONUMENTS OF THE NORTHWEST COAST INDIANS.

ceremonials, by visiting the Haida at Masset on the northern end of Queen Charlotte Island and the Nootka at villages along the western coast of Vancouver Island.

According to prominent writers the typical industry of each tribe serves as a means of commerce and trade among the neighboring tribes, the conditions of the country naturally influencing its products; for example, when the northern Indian is weaving blankets out of mountain goat wool, the southern Indian may be drying clams for the winter's food. Therefore in the first series of paintings the effect will be made to show not only the industries, but also the connections of these industries with those of other tribes. These pictures will present the scenes where the material was procured, how it was prepared, and as far as possible the use of the finished article in trade.

To gather the artistic and scientific data for the first painting of the series, showing the weaving of the Chilcat blanket, search was made through many towns and villages, often in vain, because the weather-beaten and adz-carved boards of the old houses had their original color hidden under white man's paint. In Wrangel, Mr. Taylor made many color notes valuable to his work, and he got the remainder of the subject in the Chilcat River section at Kluckwan, where two old women, seated in their peculiar fashion on their heels, were creating a blanket, stripping the cedar bark for warp, and spinning the wool from the crude wool of the mountain goat.

The Queen Charlotte Islands have long been inhabited by the most skillful builders of canoes, enormous dugouts from cedar trees. An Indian engaged at this work is represented in the accompanying view. Although no canoe was being built while he was there, one six fathoms long had been made the previous winter. The Indians were still interested in it and manifested considerable pride in showing their work. Urged on by their pride, they carefully explained details and in many cases excellently illustrated them, as a result of which dozens of pencil compositions and many local color notes were gained, so that the Haida painting will show graphically the Indians at work carving and steaming the canoe in the midst of characteristic surroundings.

On the way to Nass River they were informed that a native artist lived at Georgetown. To learn that a picture painter, not a mere decorator, existed among these serious-minded peoples who are accustomed to make only abstract designs stimulated their interest. They finally reached the shack of the artist and, watched by a large and curious family, were ushered into his "studio." He exhibited odd bits of broken glass which when held toward the light showed strange drawings in color, sometimes almost caricatures. Yet they held a certain charm, telling tales of legendary battles or of wonderful ceremonials. In spite of the difficulties in the way of his work, the man was a true artist, an eager spirit, in a race where enthusiasm is rare.

Mr. Taylor found that since the traders have taken away from the Indians all the skins and furs, tribal currency has been limited to blankets, though to a large extent it has given place to the money of the United States and Canada. He saw the Kwakitul Indian still using blankets for exchange in their potlatches. It must have been no unusual thing in the past to see ornamented natives unload canoes full of blankets, while groups of waiting "financiers" stood in picturesque arrangement before their houses and totem poles. The Tlingit exchanged their Chilcat blankets for Haida canoes. (The making of a Chilcat blanket with an Indian woman at the frame is depicted in the half-tone.) The Haida traded their canoes for the eulichon grease of the Tsimshian. The Bella-Coola who were the bread makers exchanged their bread with neighboring tribes. Thus through all the coast tribes Taylor found a distribution of industrial products going on, and to-day the results of this commerce are evident, for in the extreme south one finds the work of the tribe living farthest north, and *vice versa*.

JACQUARD LOOM IMPROVEMENT.

Interested circles have long been devoting attention to the possibility of weaving without cards, and in still more recent times to the weaving of fancy patterns in various colors by the aid of electricity. Certain inventions have been patented in this connection, and these have now been brought into a practical form. The chief object of the inventions in question has been to avoid the troublesome work in lifting the corresponding pattern cards out of the design frame. After several years' work success has at last been attained, and a machine has been constructed which is able to produce a piece of material bearing a pattern or design taken from an ordinary drawing. As the principle of this invention is such that it can be applied to a very wide field, and as it is also possible to reproduce in woven design photographs of pictures with all their lights and shades, quite a new field for Jacquard weaving will be called into existence. If it also

be remembered that, with the aid of the three-color process, it will in addition be possible to weave designs in natural colors, it will also be seen that in future many difficulties which have so far been obstacles to Jacquard weaving will now be entirely avoided. The invention in question relates to an artificial card, this being done by electric power transferred to the needles of a Jacquard loom. In other words, the Jacquard loom has now been altered in such a way that, instead of the usual Jacquard cylinder, mechanism is employed for the transmission of the electric energy mentioned above. A German professor (Prof. Regel) has now built such a machine at a factory, and we hear that the invention will shortly be in practical use.

MENDELEEFF'S LIFE AND WORK.*

THE CAREER OF A GREAT CHEMIST.

DMITRI IVANOVITSCH MENDELÉEFF† was the fourteenth and youngest child of his parents, Ivan Pavlovitsch and Maria Dmitrievna, *née* Korniléff. His father, a former student of the Chief Pedagogic Institute of St. Petersburg, obtained the appointment of director of the gymnasium at Tobolsk, in Siberia, where he met Maria Dmitrievna, who became his wife. After a few years at Tobolsk he was transferred to school directorships in Russia, first at Tambov and afterward at Saratov; but in order to satisfy the ardent wish of his wife, he took advantage of an opportunity of exchange, by which he became once more director of the college at Tobolsk, and the family returned to Siberia. Here on January 27th, 1834 (O. S.) was born Dmitri Ivanovitsch, the youngest son. Soon after his birth the father became gradually blind from cataract in both eyes, and was obliged to resign, the whole family, including eight children, having to subsist on a small pension of 1,000 roubles (about £100 per annum). The mother, Maria Dmitrievna, belonged to the old Russian family Korniléff, settled at Tobolsk. They were the first to establish in Siberia the manufacture of paper and glass. In 1787 the grandfather of Dmitri opened at Tobolsk the first printing press, and from 1789 produced the first newspaper in Siberia, the Irtysch. The glass works were situated in the village of Aremziansky, a short distance from Tobolsk.

There can be no doubt the mother was a woman possessed of remarkable vigor of mind, who exercised great influence over her children. Her activity and capacity are further illustrated by the fact that when her husband became blind she revived the business of the glass works, and carried it on until after his death from consumption in 1847.

Tobolsk was at that time a place of banishment for many political exiles, the so-called Decembrists, one of whom, Bassargin, married Olga, an elder sister of Dmitri. To these Decembrists the boy owed his first interest in natural science. His mother had always cherished the hope that at least one of her children would devote himself to science, and accordingly, after her husband's death and the destruction of the glass works by fire, and in spite of failing health and scanty means, she undertook the long and tedious journey from Tobolsk to Moscow, accompanied by her remaining children, Elizabeth and Dmitri Ivanovitsch, with the object of entering the latter, then nearly fifteen years of age, at the university. Disappointed in this object, owing to official difficulties, she removed in the spring of 1850 to St. Petersburg, where ultimately, with the assistance of the director, Pletnoff, of the Central Pedagogic Institute, a friend of her late husband, she succeeded in securing for her son admission to the physico-mathematical faculty of the Institute, together with much-needed pecuniary assistance from the government.

The debt which Dmitri Ivanovitsch owed to his mother he acknowledged later in the introduction to his work on "Solutions," which he dedicated to her memory.

In the Pedagogic Institute, Dmitri Ivanovitsch was thus able to devote himself to the mathematical and physical sciences under the guidance of Profs. Leng and Kupfer in physics, Woskresensky in chemistry, and Ostragradsky in mathematics. Unfortunately, at the end of his course his health failed, and about this time his mother died. Having been ordered to the south, he fortunately obtained an appointment as chief science master at Simferopol, in the Crimea. The southern climate soon alleviated the serious symptoms of lung disorder, and removal being necessary in consequence of the Crimean war, he was able soon afterward to undertake a post as teacher of mathematics and physics at the gymnasium at Odessa. In 1856 he returned to St. Petersburg, and at the early age of twenty-two was appointed privat-docent in the University, having secured his certificate as master in chemistry.

At this time he appears to have passed rapidly from one subject to another, but he soon found matter for serious and protracted study in the physical properties of liquids, especially in their expansion by heat; and when, in 1859, by permission of the Minister of Public Instruction, Mendeléeff proceeded to study under Regnault in Paris and afterward in Heidelberg, he devoted himself to this work, communicating his results to Liebig's Annalen and the French Academy of Sciences. Returning two years later to St. Petersburg, he secured his doctorate, and was soon afterward appointed professor of chemistry in the Technological Institute. In 1866 he became professor of general chemistry in the University, Butlerow at the same time occupying the chair of organic chemistry.

As a teacher, Mendeléeff seems to have possessed a special talent for rousing a desire for knowledge, and his lecture room was often filled with students from all faculties of the University. Many of his former students remember gratefully the influence he exercised over them.

One of Mendeléeff's most remarkable personal features was his flowing abundance of hair. The story goes that, before he was presented to the late Emperor, Alexander III., his Majesty was curious to know whether the professor would have his hair cut. This, however, was not done, and he appeared at Court without passing under the hands of the barber. His habit was to cut his hair once a year, in spring, before the warm weather set in. His eyes, though rather deep set, were bright blue, and to the end of his life retained their penetrating glance. Tall in stature, though with slightly stooping shoulders, his hands noticeable for their fine form and expressive gestures, the whole figure proclaimed the grand Russian of the province of Tver.

At home, Mendeléeff always wore an easy garment of his own design, something like a Norfolk jacket without a belt, of dark gray cloth. He rarely wore uniform or evening coat, and attached no importance to ribbons and decorations, of which he had many.

As to his views on social and political questions, many people thought him a rigid monarchist, but he said of himself that he was an evolutionist of peaceable type, desiring a new religion, of which the characteristic should be subordination of the individual to the general good. He always viewed with much sympathy what is called the feminine question. At the Office of Weights and Measures he employed several ladies, and about 1870 he gave lectures on chemistry to classes of ladies.

Mendeléeff held decided views on the subject of education, which he set forth in several publications, especially "Remarks on Public Instruction in Russia" (1901). Here he says: "'The fundamental direction of Russian education should be living and real, not based on dead languages, grammatical rules, and dialectical discussions, which, without experimental control, bring self-deceit, illusion, presumption, and selfishness." Believing in the soothing effect of a vital realism in schools, he considered that universal peace and the brotherhood of nations could only be brought about by the operation of this principle. Speaking of the reforms desirable, he says that "for such reforms are required many strong realists; classicists are only fit to be landowners, capitalists, civil servants, men of letter critics, describing and discussing, but helping only indirectly the cause of popular needs. We could live at the present day without a Plato, but a double number of Newtons is required to discover the secrets of nature, and to bring life into harmony with the laws of nature." Mendeléeff was evidently a philosopher of the same type as our own Francis Bacon.

In 1863, when twenty-nine years of age, Mendeléeff married his first wife, *née* Lestshoff, by whom he had one son, Vladimir,* and a daughter, Olga; but the marriage proved unhappy, and after living apart for some time there was a divorce. In 1881 he married a young lady artist, Anna Ivanovna Popova, of Cossack origin, and lived first at the University and afterward in the apartments built for the director at the Bureau of Weights and Measures. Here his younger children were born, Lioubov (Aimée), Ivan (Jean), and the twins, Maria and Vassili (Basile).

In 1890, in consequence of a difference with the administration, Mendeléeff retired from the professorship in the University. During the disturbances among the students in that year, he succeeded in pacifying them by promising to present their petition to the Minister of Education. Instead of thanks for this service, however, the professor received a sharp reprimand from the authorities for not minding his own business. The consequence was that Mendeléeff resigned. Independently of the petition, however, there were probably deeper reasons for his being out of favor with the Ministry, connected with his irreconcilable enmity to the classical system of education already referred to. Of this he made no secret, and it had already brought him into conflict with the authorities. In 1893, however, he was appointed by M. Witte to the office of Director of the Bureau of Weights and Measures, which he retained until his death.

Such are the chief features of a great personality. If it be admitted that stories are told of his occasional irritability of temper, we can well place on the other side of the account the cordial relations always subsisting between the professor and his assistants, the confidence and respect between the master and his servants, the deep affection between the father and his children, which are known to have persisted throughout his life, and which could be illustrated by many anecdotes. These stories merely serve "to give the world assurance of a man."

For us who live on the other side of Europe, separated as we are by race, by language, by national and social customs, and by form of government, it is not easy to understand completely the texture of such a mind, the quality of such genius, and the conditions, social or political, which may have served to encourage or to repress its activity. The Russian language may be eloquent, expressive, versatile, and harmonious, or it may possess any other good quality that may be claimed for it by those to whom it is a mother tongue, but the fact remains that it is a barrier to free intercourse between the Russian people and the world outside the Russian empire. This alone creates a condition which must influence the development of thought, and must give to Russian science and philosophy a color of its own. Mendeléeff was, like many educated Russians, a man of very liberal views on such subjects as education, the position of women, on art and science, and probably on national government. We can hardly guess what would be the influence on such a nature of a rigid administrative *régime* which forbids even the discussion of such questions. We in England are almost unable to imagine such a state of things as would be represented by the closing of, say, University College for a year or more, because the question whether the House of Lords ought to be abolished had been debated in the Students' Union. Imagine the professor of chemistry, along with his colleagues, for such a reason deprived of the use of his laboratory by the police, and only allowed to resume his studies when someone down at Scotland Yard thought proper. Such being the experience of most of the Russian universities and technical high schools, it is not surprising that the output of Russian science, notwithstanding the acknowledged genius of the Russian people, appears sometimes comparatively small. The amount of work done by Mendeléeff, both experimental and theoretical, was prodigious, and all the more remarkable considering the cloudy atmosphere under which so much of it was accomplished.*

In 1882 the Royal Society conferred on Mendeléeff, jointly with Lothar Meyer, the Davy medal. In 1883 the Chemical Society elected him an honorary member, and in 1889 it conferred upon him the highest distinction in its power to award, namely, the Faraday lectureship, with which is associated the Faraday

* The Mendeléeff Memorial Lecture delivered before the Chemical Society on October 21, 1909, by Sir William A. Tilden, F.R.S. Abridged from the Journal of the Society for December, 1909.

† For many of the details of Mendeléff's career and of his home life the writer is indebted to the family chronicle compiled, soon after his death, by his niece, N. J. Gubkina (*née* Kapustina), and published in St. Petersburg, also to pamphlets by A. Archangelsky and P. J. Robinowitsch. He also desires to express his thanks to Mr. D. V. Jéquier, of St. Petersburg, as well as to several Russian friends, for valuable assistance in translation.

* Died in 1899, aged thirty-four.

* Prof. Walden, at the end of a biographical notice recently published in the Berichte d. Deut. Chem. Ges., April, 1909, gives a list of 262 printed publications by Mendeléeff. These include, not only memoirs on physical and chemical subjects, but books, pamphlets, reports, and newspaper articles relating to exhibitions, to the industries of Russia, to weights and measures, to education, to art, and even to spiritualism.

medal. In 1890 he was elected a Foreign Member of the Royal Society, and in 1905 he received the Copley medal. So far as England is concerned, his services to science received full acknowledgment. It is all the more remarkable, therefore, that he never became a member of the Imperial Academy of Sciences of St. Petersburg.

Toward the end of 1906 Mendeléeff's health began to fail. Nevertheless he was able to attend the Minister on the occasion of an official visit in January to the office of Weights and Measures, but he caught cold and, enfeebled as he had been by influenza in the preceding autumn, inflammation of the lungs set in. Retaining consciousness almost to the last, he requested even on the day of his death to be read to from the "Journey to the North Pole," by his favorite author, Jules Verne. He died in the early morning of January 20th (O. S.), 1907, within a few days of his seventy-third birthday. He was buried in the Wolkowo Cemetery beside the graves of his mother and son.

Turning now to a survey of Mendeléeff's work as a man of science, it will be sufficient if we pass lightly over his first essays. Like so many other chemists, he began by handling simple questions of fact, his first paper, dated 1854, when he was twenty years of age, being on the composition of certain specimens of orthite. It was not until 1859 that he settled down to serious examination of the physical properties of liquids, which led him to a long series of experiments on the thermal dilatation of liquids, of which the chief ultimate outcome was the establishment of a simple expression for the expansion of liquids between 0 deg. and the boiling point. This formula is liable to the same kind of modification which has been found necessary in the case of gases. It is, of course, applicable only to an ideal liquid from which all known liquids differ by reason of differences of chemical constitution and consequent differences of density, viscosity, and other properties.

Mendeléeff devoted a large amount of time and of experimental skill to the estimation of the densities of various solutions, especially mixtures of alcohol and water and of sulphuric acid and water, and of aqueous solutions of a large number of salts. In 1889 he embodied the whole in the monograph already referred to. In a paper communicated to the Transactions in 1887 (ii., 779), he stated his views in the following words: "Solutions may be regarded as strictly definite atomic chemical combinations at temperatures higher than their dissociation temperatures. Definite chemical substances may be either formed or decomposed at temperatures which are higher than those at which dissociation commences; the same phenomenon occurs in solutions; at ordinary temperatures they can be either formed or decomposed." These views, however, did not prevent his recognizing Van 't Hoff's gas theory as applicable to dilute solutions.

In conjunction with some of his students, Mendeléeff also studied minutely the question of the elasticity of gases, and published several papers on the subject (see Royal Society Catalogue), extending over a period of some ten years from 1872.

Another subject to which Mendeléeff gave a good deal of attention was the nature and origin of petroleum. Having already reported in 1866 on the naphtha springs in the Caucasus, in the summer of 1876 he crossed the Atlantic and surveyed the oil fields of Pennsylvania. In the course of these investigations, he was led to form a new theory of the mode of production of these natural deposits. The assumption that the oil is a product of the decomposition of organic remains he rejects on a variety of grounds, which are set forth in a communication to the Russian Chemical Society (Abstract, see Ber., 1877, x., 229). Mendeléeff assumes, as others have done, that the interior of the earth consists largely of carbides of metals, especially iron, and that hydrocarbons result from the penetration of water into contact with these compounds, metallic oxide being formed simultaneously. The hydrocarbons are supposed to be driven in vapor from the lower strata, where temperature is high, to more superficial strata, where they condense and are retained under pressure. In 1886, in consequence of rumors as to the possible exhaustion of the Russian oil fields, he was sent by the government to Baku to collect information, and in 1889 he made a communication on this subject to Dr. Ludwig Mond, which is printed in the Journal of the Society of Chemical Industry (1889, viii., 753).

The influence of the great generalization known as the periodic law can best be estimated by reviewing the state of knowledge and opinion before the announcement and acceptance of the principle by the chemical world, and subsequently glancing at the influence which, directly or indirectly, it has produced on scientific thought, not only in regard to the great problems to which it immediately relates, but to the whole range of chemical theory.

The use of the expression "atomic weight" implies the adoption of some form of atomic theory; but forty or more years ago Dalton's atomic theory was by many of the most philosophical chemists and physicists regarded as only a convenient hypothesis, which might be temporarily useful, but could not be accepted as representing physical reality. Since that time, however, a variety of circumstances have contributed to consolidate the Daltonian doctrine. The estimation of the ratios called atomic weights has been the subject of research, attended by more and more elaborate precautions to secure accuracy, from the time of Dalton himself onward through successive generations down to the present day. Though the atomic weights of the majority of the common elements are now known to a high degree of accuracy, the acknowledged errors have been sufficiently great to render abortive various attempts to reduce them to any common scheme of mathematical relationship. As is well known, the most important step toward the systematization of atomic weights was taken about 1860, mainly on the grounds eloquently and convincingly set forth by Cannizzaro,* in consequence of which the arbitrary selection of numbers for atomic weights was superseded by the practical recognition of the law of Avogadro and the application of the law of Dulong and Petit, so that a common standard was established. No general scheme of atomic weights was previously possible, partial and imperfect efforts in this direction being represented by Dœbereiner's triads and the principle of homology made use of by Dumas. Only so soon as numbers representing the atomic weights of calcium, barium, lead, and other metals were corrected and brought into the same category as those of oxygen, sulphur, and carbon was there some chance of determining whether these numbers possessed a common factor or were capable of exhibiting mathematical inter-relations which might be regarded as symbolic of physical relations or even directly dependent upon them. The first step in this direction was taken by J. A. R. Newlands, who, after some preliminary attempts in 1864-5, discovered that when the elements are placed in the order of the numerical value of their atomic weights, corrected as advised by Cannizzaro, the eighth element starting from any point on the list exhibits a revival of the characteristics of the first. This undoubtedly represents the first recognition of the principle of periodicity in the series of atomic weights, but whether discouraged by the cool reception of his "law of octaves" by the chemical world or from imperfect apprehension of the importance of this discovery, Newlands failed to follow up the inquiry. It was not long, however, before the matter was taken up by others, and doubtless the improvements in the estimation of atomic weights, following on the work of Stas, then only recently published, inspired greater confidence in the approximate accuracy of the numbers adopted as atomic weights, and thus encouraged inquiry into their relations. The subject is, indeed, an attractive one, for it involves considerations which lie at the foundations of all our notions respecting the physical constitution of matter, and accordingly we find papers by many chemists dealing with the question of these numerical relations. Odling especially seems to have given much thought to the subject, and, ignoring Newland's previous attempts, he drew up toward the end of 1864* a table containing all the at that time well-known elements, arranged horizontally in the order of their generally accepted groups, and perpendicularly in the order of their several atomic weights. He concludes an article in Watts's Dictionary a few months later with these words: "Doubtless some of the arithmetical relations exemplified in the foregoing table are merely accidental, but, taken altogether, they are too numerous and decided not to depend on some *hitherto unrecognized* law." It is important to note the words I have italicized.

Such, then, was the state of knowledge about this time. Evidently the way was being prepared, but the prophet had not made his appearance—the seer who could look with the eyes of confidence beyond the clouds of uncertainty which obscured all ordinary vision.

(To be concluded.)

* 1858, and later, Faraday Lecture, 1872.

* Quart. J. Sci., 1864, i. 644; and Watts's Dictionary, vol. iii, 975.

THE PURPLE OF THE ANCIENTS.

Most highly prized among the ancients, of all the dyestuffs known to them, was the so-called purple, a color prepared from certain marine snails. Our knowledge of this substance is derived largely from Greek and Roman writings, but there can be no doubt that the origin of the art of making and using this dye lies far back in remote antiquity. The Greeks themselves ascribed the discovery of the dye to their mythological hero Hercules, whose dog picked up a snail on the shore, and, breaking the shell, disclosed to his master the staining properties of the mollusk. As a matter of fact the art of dyeing with purple seems to have been introduced by the Phenicians, and it is among the Semitic races that the earliest records relating thereto have been found. According to Dedekind a passage in an ancient Egyptian poem dating from 1400 B. C. must be construed as referring to the purple snail. In the Old Testament, too, we read of curtains of purple draping the entrance to the Holy of Holies in Solomon's temple. And the same source tells of purple robes of state worn by the high officials of the Persian king.

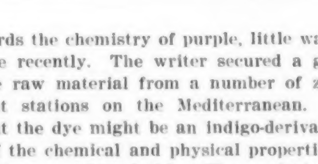
With the growth of civilization among the Mediterranean nations, and the increase of wealth, the use of purple became more general, and at the time of the Roman empire had degenerated into a luxury indulged in without moderation by the rich. Nevertheless the wearing of special forms of purple garments remained the privilege of certain classes, the "purpurati."

After the overthrow of Rome by the barbarians the industry became centered principally at Constantinople, where it was carried on under royal monopoly, and gradually degenerated and finally became practically extinct. It is for this reason that only among very early manuscripts, dating from the twelfth and thirteenth centuries, so-called codices purpurei, written upon parchment dyed with purple, are found.

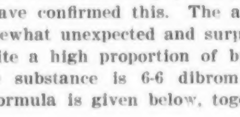
Strangely enough, we have but a vague idea of the actual color and appearance of the proverbial "purple" of the ancients. One result of this is that, as a designation of a modern color, there is considerable divergence in the significance of the word purple, as used in English, and the corresponding "pourpre" in French and "purpur" in German. These latter correspond more nearly to our crimson. It is very probable that the most valuable purple was a very dark color, almost black, with a bluish or reddish violet sheen by reflected light. But it seems that there were also lighter shades, produced by the admixture of various substances to the dye. The true color of the ancient purple could of course be established beyond doubt if it were posssible to follow out some of the old recipes. Unfortunately this is not feasible. The available data, as found especially in Pliny's writings, are too vague, and in part quite unintelligible. This only is known with certainty, that the species of snail named by Pliny "purpura" is known in modern zoology as Murex brandaris, while the bucinum of Pliny is a species of purpura, probably P. hemostomata.

Nothing definite is known as to the amount of raw material which was required to make a pound of the dye. But it must have been very large, and this was no doubt the reason for the excessively high price of the product. As regards this we are told that at the time of Diocletian the best qualities of purple wool sold at $238 per pound. When we reflect that such material would contain only 4 to 5 per cent at most of the dye we see that our modern producers have cause to envy the makers of those days for the prices which they could command.

As regards the chemistry of purple, little was known until quite recently. The writer secured a good supply of the raw material from a number of zoological experiment stations on the Mediterranean. He suspected that the dye might be an indigo-derivative, and a study of the chemical and physical properties of the substance have confirmed this. The analysis brought out the somewhat unexpected and surprising fact that there is quite a high proportion of bromine present. In fact the substance is 6-6 dibrom indigo, whose structural formula is given below, together with that of indigo:



6-6 Dibrom-indigo



Indigo

It is interesting indeed to note that the famous dye of the ancients is so close a relative to one of our most valued coloring matters to-day, namely, indigo. The same indigo which but a few years ago was put upon the market as a synthetic product born in the chemical laboratory, threatening the life of the old natural indigo industry, and furnishing a most brilliant example of the triumphs gained in the industries over the old empirical methods, by the applications of modern science.—Translated for the Scientific American Supplement from Zeitschrift fuer Angewandte Chemie.

INSTANTANEOUS MICROPHOTOGRAPHY.

ITS APPARATUS AND TECHNIQUE.

Instantaneous microphotography presents very great interest, especially when it is desired to fix exactly the forms of certain living microscopic animals, such as infusoria, which cannot be made motionless by chemical reagents without greatly changing their appearance, often to such a degree as to make them unrecognizable. It is particularly difficult to seize the images of these microscopic creatures, the movements of which are very rapid and are exaggerated in proportion to the enlargement. The principal object of all the special apparatus used in microphotography is to permit the operator to observe, by means of a special eye-piece, the object to be photographed, so that he can make the exposure exactly at the moment when, owing to the combined motions of the microscope stage and the focusing screw, the object is both in a good position and sharply defined.

From what was said above concerning the rapidity of the movements of infusoria, it will be seen that it is necessary to use a so-called instantaneous exposure, which must be made shorter in proportion to the degree of enlargement.

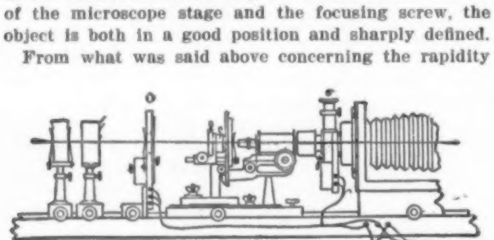


Fig. 1.—BRIANDEAU'S APPARATUS FOR INSTANTANEOUS MICROPHOTOGRAPHY.

As the brightness of the image diminishes in the same proportion, very powerful sources of illumination, such as the sun or the electric arc, must be employed. In the path of the incident beam it is necessary to interpose a vessel filled with a transparent liquid (glycerine or a solution of alum) for the purpose of absorbing the greater part of the rays of long wave length, which would kill the animalcules by heating the liquid which contains them. The eye of the observer must be protected against the action of this very brilliant illumination by covering the eye-piece with smoked glass.

In order to overcome all these difficulties, Briandeau has designed the apparatus described below, with which he has obtained really remarkable results. The special features of the apparatus are two shutters, connected with a device for simultaneous vision of the object. These two shutters, the first of which, strictly speaking, serves only to diminish the intensity of the illumination during the ocular observation, are electrically connected with each other, so that the second shutter operates automatically immediately after the first. The first shutter O (Fig. 1) is pierced by a circular opening, the center of which coincides with the optical axis of the microscope. To the shutter is attached a vertical groove, in which slides a sheet of metal having two apertures which can be placed in succession opposite the hole in the shutter. The upper aperture in the metal plate is entirely open, while the lower one is covered with a smoked glass of any desired tint, so that the light passing through it is diminished sufficiently to allow the object to be viewed directly without fatigue, and to protect the organisms in the preparation from the injurious effects of excessive light. When the shutter O is set ready for action, this smoked glass is interposed in the path of the luminous beam. At this moment a spring r (Fig. 3) presses upon a contact piece c and establishes an electric connection between the battery P, the releasing mechanism of the shutter E and the key C, which is pressed by the operator at the moment which he judges most opportune for the exposure. The shutter, being thus released, slides downward by its own weight and allows the beam of light to pass with undiminished intensity through the upper aperture. When the shutter arrives at the end of its course its lower edge presses the spring r toward the left, breaking the contact c, but establishing through the contact c an electric circuit which extends directly from the battery to the releasing mechanism E of the second shutter O', which is really the true photographic shutter that permits the luminous pencil produced by the magnifying optical system to form the image on the photographic plate. This second shutter O' is placed as near as possible to the projecting lens of the eye-piece (Fig. 2). The shutter consists of a semi-circular plate, having an opening considerably larger than that of the external diaphragm of the eye-piece. By the side of the aperture is placed a total reflection prism, so arranged that when the shutter is set the pencil of light emerging from the eye-piece is deflected at right angles and along the line of sight of a small telescope, which can be adjusted in such a manner that the image seen directly is as sharp as the image projected upon the sensitive plate of the camera.

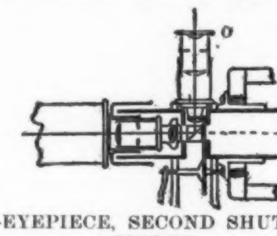


Fig. 2.—EYEPIECE, SECOND SHUTTER, AND FINDER.

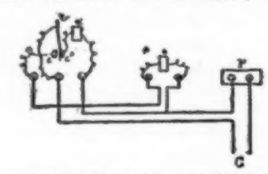


Fig. 3.—ELECTRICAL CONNECTIONS.

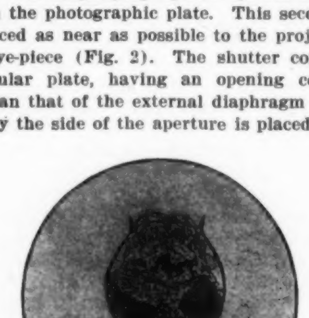


Fig. 4.—INSTANTANEOUS PHOTOGRAPH OF A WHEEL ANIMALCULE.

(Magnified about 100 diameters.)

The two shutters having been set, the animalcule to be photographed is selected, followed and kept in focus until the moment which is deemed favorable for making the picture. The operator then presses the electric key c, the effect of which is to release the first shutter O, the fall of which in turn releases the second shutter O' as soon as the illuminating beam of light has been entirely unmasked. Very interesting results can be obtained with this comparatively simple apparatus.—La Science au XXme Siècle.

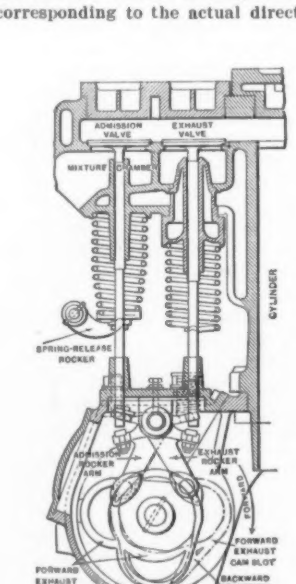
A NOVEL REVERSING GASOLINE ENGINE.

The Howaldswerke, of Kiel, Germany, has developed a reversible internal-combustion engine which embodies some interesting features.

It is a vertical, single-acting, four-stroke engine, operated by any volatile fuel, such as benzine, gasoline, or even alcohol. The cylinders are bolted to a closed crank case, and provided with removable heads. As shown, both the barrel and the head are provided with water jackets.

The piston, which is of the trunk type, ground to its final diameter, is provided with packing rings of cast iron. The piston pin is of hardened steel, ground to size. The crank shaft is of high-grade steel, forged in a single piece, and runs in bearings of ample dimensions, which are lined with white metal. The cam shaft, which rotates at half the speed of the crank shaft, is located parallel to the latter, from which it is driven through the usual spur gearing. From the cam shaft is driven all the accessory mechanism of the motor—valves, pumps, and ignition devices. Separate suction and main-admission valves are provided, the latter being operated from the cam shaft, while the former are driven either in the same manner or independently of that shaft, being opened by the vacuum produced in the cylinder by the motion of the piston, and closed by a spiral spring as soon as this vacuum ceases. The mechanically-operated valves are operated through slotted cam disks mounted on the cam shaft. The valves are all made of nickel steel, and the automatic suction valves used on the small engines are of a specially practical and light construction, allowing of a rapid opening and closing, and reducing the resistance to the gas flow.

The figure shows the arrangement of the reversing valve gear. Slotted cam discs are mounted on the cam shaft for actuating the admission and exhaust valves. Each disk is provided on one of its plane faces with two cam slots, in which moves a slide pivoted on one arm of a bell crank, the other end of which lifts the valve stem. These slots are so designed that the valves are lifted uniformly with both directions of rotation. The slide and the slots are so designed that the former is compelled to move in the slot corresponding to the actual direction of rotation as long as that direction is maintained, but will automatically enter the slot corresponding to the other direction, as soon as the engine is reversed.



REVERSING VALVE GEAR OF ENGINE.

The engine is reversed simply by shifting the ignition timer, with any other manipulation of the engine. When the engine is running at slow speed, moving the "spark lever" to the "backward" position shifts the timer so as to produce ignition during the compression stroke, long before the piston has completed the stroke, and the back pressure on the piston is sufficient to overcome the inertia of the flywheel and reverse the direction of rotation. The succeeding ignition then is not advanced, but, owing to the reversal of the engine, becomes a late ignition. By then shifting the lever to the "full" position the timer is adjusted for the ignition to occur at the proper point to give maximum power. During reversal the load is thrown off, of course, by throwing out a flywheel friction clutch by means of a pedal.

On the cam shaft are also mounted two eccentrics which operate the cooling water and the oil pumps. The former is a piston pump with suction and pressure valves, provided with rubber disks to insure noiseless working; the latter is also a piston pump, but it is provided with ball valves. On the cam shaft is finally mounted the ignition timer. A battery current and an induction coil are used to produce high-tension current for "jump spark" ignition, and in the smaller engines this is the only ignition mechanism. In the large-sized engines there is also provided a magneto operated from the cam shaft through gears.

The fuel is gasified by a carbureter provided with means for regulating the mixture ratio for full and slow speed respectively, and the carbureter is warmed by means of the exhaust gases of the engine.

For use in marine service the motor is controlled by a maneuvering board mounted on a support, by means of a hand wheel and small lever, the motion of the wheel and lever being transmitted mechanically through wire ropes to the ignition timer and carbureter respectively.

A friction clutch, with disengaging forks, is arranged inside the flywheel and controlled by a pedal, allowing the propeller to be thrown into and out of gear with the engine, as in the case of an ordinary automobile clutch and transmission.—Power and the Engineer.

THE TRANSFER OF HEAT IN SOILS.*

AN INSTRUCTIVE INVESTIGATION.

BY HARRISON E. PATTEN.

THE writer has recently investigated the absorption of heat by soils, working out a new experimental and theoretical treatment of heat transference† which may prove of interest to others than soil investigators. Hence an outline of the work is given here.

At first sight it would seem very simple to insert a thermometer in the soil at any desired depth and read from it the temperature. And so it is. Much valuable information as to soil temperature and crop growth has been obtained in this way. But if we attempt to find out just what climatic causes, such as frost, excessive heat, rain, snow, wind velocity, shelter from winds, slope, drainage, exposure, altitude, humidity of atmosphere, etc., produce the degree of temperature observed at any point in a soil, the problem becomes very complex. Thus far, the work, both of practical soil investigation and of purely physical researches, has failed to show the proper relation of the various causes to the travel of heat to and fro in a soil. Some of these causes assist the flow of heat; some, on the other hand, retard its progress.

The energy available for all activity on the earth's surface comes to us from the sun and from other suns in space. Just how this energy is transported across these tremendous distances for our use here on earth is a mystery. We have found out experimentally, however, (1) that this energy arrives in a regular series of shocks, and (2) that there are a number of different sorts of these series of shocks or waves. They can be separated from each other giving the various kinds of light, red, blue, violet, etc., heat, electricity, X-rays, etc. Moreover, these different forms of energy may be converted into each other.

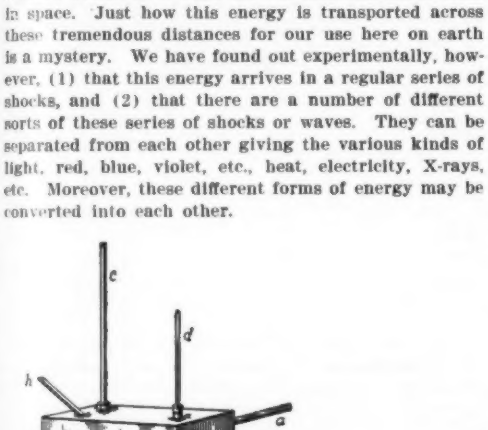


FIG. 1.—HEAT SOURCE USED IN THIS INVESTIGATION.

Thus, the energy in sunshine is practically all in the form of light, or short waves; but when it strikes the earth's atmosphere part of the sunshine is absorbed by the air in another form, as heat. Part of the sunshine is reflected back to stellar space, and still another fraction of the sunshine passes down to the earth, where it is partly reflected and partly converted to heat. The heat then travels downward into the earth as more and more sunshine strikes and warms the surface. When the sun begins to sink, less and less sunshine strikes the earth and its surface cools until presently we have the stored heat of the day traveling back from the lower layers of soil up toward the surface. The heat lost from the earth's immediate surface may be given forth not as heat but as radiant energy. Consequently we may have a very hot day followed by a very cold night in regions where there is little moisture in the air. This is because the hot soil gives off its heat again as radiant energy (not as heat); and thus the day's store of warmth escapes without warming up the night air. But in moist regions, the escaping radiant energy on meeting the water vapor in the air, is converted back to heat. Some of the sunshine on striking the earth serves to evaporate water, and thus is converted by expansion of the vapor into mechanical energy; condensation of this vapor to water, as rain and sleet and snow, liberates heat and in falling and moving through the air produces electricity, which we see occasionally in the form of lightning.

It is evident then, that the actual quantity of heat supplied to the surface of the earth in any one spot depends upon many atmospheric conditions. The continual change in each of these conditions from hour to hour renders difficult the estimation of an average value of the heat supplied to a given area of soil during a known interval of time. In this case it seems that the most practical means of finding out the laws of heat-flow through soil is not to work in the field where every condition we desire to study changes at its own will and in unknown degree, but rather to know and control each of these conditions.

Although measurement of soil temperature has been

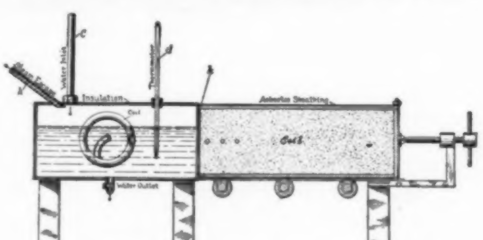


FIG. 2.—LONGITUDINAL SECTION OF HEAT SOURCE WITH SOIL BOX IN POSITION.

carried on in many countries for many decades, there seems to be no investigation on record giving the rate of flow of heat through soil under controlled laboratory conditions where the moisture content, packing (apparent specific volume), and effective specific heat are known. In some cases accurate daily readings of the soil temperature have been taken to a depth of three feet or more through a series of years, but no attempt made to measure, even roughly, the moisture content, the apparent specific volume, or the specific heat. Other observers have recognized the need of all these additional factors, and have at times secured data on them under field conditions; but even then we can not calculate the heat conductivity of the soil from their readings with any degree of satisfaction, since the moisture content varies with the depth and we must take temperature readings at several depths to determine the temperature wave.

The investigators in this line of work have been interested mainly in ascertaining the temperature of the soil at given depths during the growing season. Some have tried the effect of various top dressings—manure admixtures, mulches, rolling, etc.—upon the soil temperature, and many of these results are valuable and reliable since they were obtained under comparable though undetermined conditions. Others, too, have recognized the part which the total quantity of available heat plays in the development of plants, and attempts to measure this heat have been made by integrating the air temperatures close to the ground and integrating the sunshine. Such calculations are also supplemented by an integration of the heat gained by the soil from day to day as the season progresses.

From another standpoint geologists and astronomers have made daily measurements of temperatures at regular depths in solid rock for periods even approaching half a century on one single series, and have accurately calculated the heat conductivity of the rock. But such values for the heat conductivity of a homogeneous or compact rock conglomerate do not help much in estimating the conductivity of a soil.

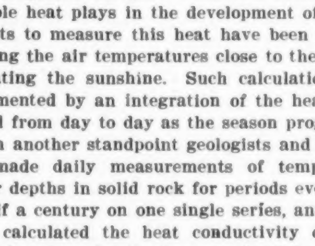


FIG. 3.—SOIL BOX, SHOWING ARRANGEMENT OF THERMOMETERS.

Much time has been devoted to the laboratory study of the heat relations of soils, such as heat capacity and the effect of soil moisture upon it; demonstration that the heat capacity of a powder consisting of different minerals, each with its own specific heat, is the sum of the heat capacities of its constituents; the effect of top dressings and admixtures, etc. Especially interesting is the laboratory work of Petit upon the penetration of frost into soils. He found that the phenomenon of supercooling, such as is observed in the freezing of water in the form of drops or in capillary tubes, also occurs in the freezing of soil water, and may be as great as 3 deg. C. below the freezing point of water. The lower the moisture content of the soil and the greater the energy with which the water is held by the soil, the lower is the temperature to which soil water can be supercooled. The passage of frost into the ground is fastest for quartz sand, slower for clay, and slowest for humus (peat). During continued frost the soil temperature sinks after freezing, faster and deeper, the lower the moisture content of the soil, and conversely for the thawing of a soil. Living or dead vegetation or snow protects from frost and retards thawing.

The heat conductivities of dry powders and soils have been determined by numerous experimenters, but the effect of moisture upon the heat conductivity has been treated only qualitatively. Consequently an attempt was made in this investigation to establish a quantitative relation between the heat conductivity of a powder and its moisture content. Since the apparent specific volume and effective specific heat of a powder are factors in determining its heat conductivity, these, too, were determined in every case. The rate of warming (diffusivity) of the powder, of course, was found in order to calculate the heat conductivity.

The importance of such an investigation is apparent upon reading the reports of experiment stations generally, both in this country and abroad, since large sums of money and patient observation and experimentation are involved in the attempt to ascertain the relation of temperature in air and in soil to crop growth. So long as the factors which control heat conduction remain undetermined as to their magnitude and direction of influence, much of this field work upon soil temperatures will be in vain.

Usually the heat conductivity of the earth's crust has been determined by taking the temperature of the

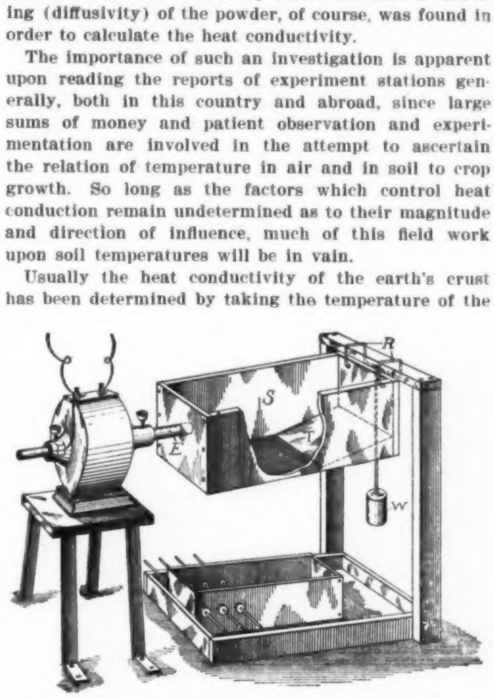


FIG. 4.—MECHANICAL PACKER, SHOWING SOIL BOX BELOW.

earth at different depths as affected by the alternate heating and cooling at the surface, due to the change from night to day, and in a greater degree as affected by the progression of the seasons.

Such measurements give the temperature wave at each depth very well for the particular locality studied, and when the specific heat of the dry soil, the per cent of water, and the specific volume (or packing) are known, one may calculate the heat conductivity of the soil. This calculation, however, involves the treatment of a periodic function which only approximates a sine curve, since it is modified by a damping term as well as by other disturbing factors. Consequently, the heat conductivity calculated in this manner is at best an approximation. Further, as the heat wave penetrates into the earth, distillation of moisture takes place accompanied by a change in packing, so any method of measuring heat conductivity which requires the soil to be subject to a difference of temperature for a short period cannot be expected to give even approximately accurate results.

The selection of a method for measuring the passage of heat through a moist soil under laboratory conditions involves a choice of the least of several evils. There is no good method. Briefly, the situation is this: If the heat be measured by extracting it from the soil, distillation ensues and the soil-crumb structure is altered: if heat be added, the same process is gone through in the reverse sense; if alternate heat and cold be applied, the soil changes its packing and may change its moisture content. In the face of these conditions it was decided to supply heat, from an infinite source at a constant temperature, to the end of a soil column and take the rate of rise of thermometers at regular distances down the column, and base a calculation of the heat conductivity upon the behavior of

* Published by permission of the Secretary of Agriculture.

† Bull. No. 59, Bureau of Soils, U. S. Department of Agriculture, 1909.

that portion of the soil which was sufficiently removed from the source of heat to be very little changed by distillation of its moisture and yet close enough to show the influence of the heat.

The apparatus used in this method consists in the main of three distinct features: (1) The heat source; (2) the soil box; and (3) the mechanical packing apparatus.

(1) The heat source is a heavy rectangular brass tank, 17 centimeters wide, 12 centimeters deep, and 20 centimeters long, insulated with asbestos and felt on five sides, one end being exposed to serve as a heat-contact. The tank is maintained at a constant temperature, near 100 deg. C., by boiling water in it and allowing the steam to escape (*h*, Fig. 1) at atmospheric pressure. For lower and higher temperatures, different liquids may be used. The liquid in the tank is very conveniently heated by a copper coil carrying live steam (*a*) which passes horizontally through the tank. The steam exhausts into a drainpipe where it is condensed by running water. The level of the water in the tank is shown by the gage *b*, and as the water boils away, the supply is replenished by the feed-pipe, *c*. The temperature of the tank is given by the thermometer, *d*; *e* and *f* are skids for the soil box, and *g* is a screw clamp serving to press the soil box firmly in place against the heat source.

(2) The soil box is built of pine wood boiled in paraffin and painted with asphaltum. One end is made of copper. Externally it has a coating of asbestos board cemented to the wood. The end cross section inside the box is 10 by 10 centimeters. Centigrade thermometers, reading 110 deg., are inserted through rubber stoppers in the sides of this box at intervals of 1 centimeter, the even positions alternating with the odd positions on opposite sides of the box, thus, numbers, 1, 3, 5, 7 are on the right side of the box, and numbers 2, 4, 6 on the left side (Fig. 3). The thermometer bulbs are ranged along the central diameter of the box, which is perpendicular to the plane of the heat source. For some of the determinations thermometers were placed above and below this central diameter to ascertain the effect, upon the rate of the temperature rise with time of departure from this central diameter.

In making a determination the soil box is fitted with the thermometers and then filled with soil of definite moisture content from the mechanical packing device to be described below. The soil box is then allowed to stand until the thermometers are nearly in a steady state at room temperature and the reading of each thermometer at "zero" time taken. The copper end of the soil box (*K*, Figs. 1 and 2) is then placed against the heat source, a stop watch pressed at the instant of contact, and readings of time and temperature taken from each thermometer during a period which may cover twenty minutes or two hours, depending upon the heat conductivity of the soil.

(3) The mechanical packing apparatus used is shown in Fig. 4. It consists of an electric motor whose shaft bears an eccentric collar *E* fitting into a hole in the end of a sieve *S*. When the motor is going the sieve vibrates rapidly at its lower end, the upper end being held in place by wire hooks *R*, which engage a support and are kept in place by the pendant weight *W*. The tin false bottom *T* feeds the soil to the screen, which had three meshes to the centimeter in the work here presented. The soil box (Fig. 3) may thus be filled with soil under definite mechanical conditions. In all the experimental determinations of heat conduction the soil was packed by means of this device, the height of the sieve above the soil box being always the same.

Experiments made with different soil types show very well the general laws of heat transference in moist powders. Wetting a dry powder increases its ability to conduct heat as much as three or four times. The reason for this increase is simple: solid sandstone transfers heat some ten times faster than the same stone ground down to small sand grains. This is because air between the sand grains prevents the ready passage of heat from grain to grain. When water is added to dry sand it places the sand grains in more intimate contact by forming a film of water which incloses each grain and fills more or less completely the angular spaces between them. Thus the water film acts as a bridge from grain to grain. Heat will pass from soil grain to water about 150 times easier than from soil grain to air; and besides, the conductivity of water is much greater than that of air. Consequently a moderately wet soil conducts heat very much better than a dry soil.

As we add more water to a soil its grains gather into clusters. This is due to the attempt of the water film, which surrounds each grain and connects them, to draw together and occupy as small an area as possible. The forming of these clusters of grains leaves larger air spaces in the soil than those in a dry soil where the grains are not united. And these large air spaces offer resistance to the passage of heat. Thus the action of water upon soil first makes better contact between individual grains, and then as more water is added it draws the grains into clusters (soil-crumbs) and produces poorer contact between the clusters, while at the same time better contact between the grains in each cluster is secured. When sufficient water is present to form practically all the soil grains into clusters the soil is in a very open condition—"crumbly." This is the most favorable condition for penetration by plant roots; the large air spaces between the soil clusters permit ventilation, and access of atmospheric gases necessary to plant growth. The per cent of moisture in a soil which produces this most favorable structure of the soil grains is technically termed the "Optimum water" content.*

When too much water has been added to a soil, the excess is held between the soil grain clusters, thus giving better contact and better heat conductivity. Consequently the heat is better able to penetrate the soil and cause evaporation of water until the right quantity of water is left for plant growth. However, a very large excess of water in a soil causes it to flow; the soil clusters are broken down to very small clusters or to single soil grains. In this condition the soil conducts heat much less well than when it has just enough water for good plant growth. This is because the water itself has a heat conductivity about one-seventh as great as that of the solid soil grains; and in addition, the capacity of water for heat is five times greater than that of dry soil grains.

The general effect of adding a liquid to a dry powder is first to increase its heat conductivity; and then as more and more liquid is added, the heat conductivity increases to a maximum value and falls again to a lower value as the powder becomes soaked and finally flows. The soaked soil, however, has a much better heat conductivity than the dry powdery soil; and soil containing the proper amount of water for plant growth has nearly the highest thermometric conductivity.

This is another beautiful illustration of the adaptation of life to environment; the structure and ventilation and moisture in a soil are all capable of being brought simultaneously into a highly favorable state for plant growth; and now it appears that a soil in this condition will also be warmest.

A very interesting fact regarding the action of water upon dry soil has been carefully considered in all of this research. It has been known for many years that heat is given out when a dry powder is moistened, but no one has thought this quantity of heat important in determining the heat capacity of powders and soils. The usual method of finding the heat capacity of a solid or solid powder is, to heat a weighed quantity of solid to a known temperature and then drop the hot solid into a known weight of water. A portion of the heat passes from the solid into the water, thus warming it. The number of degrees through which the water is warmed is read upon a sensitive thermometer immersed in it. Thus we are able to calculate the heat capacity of the solid as compared to that of the water. Now if a powder be treated in this manner to determine its heat capacity, it gives out more heat than it would give in solid unpowdered condition. In the case of a soil rich in organic matter the heat evolved on moistening the soil at room temperature was found to be one-third of the total heat given out in determining the heat capacity of this soil by the method just described. This means that the heat capacity of this soil, and others like it, has therefore been given a value one-third too high. The old figure gave such a soil a heat capacity 0.24 of that of water, which has the highest heat capacity of any known substance and therefore is chosen as the unit of heat capacity, whereas the new figure obtained is almost 0.16. In all the soils studied this correction was made. It is very considerable for soils containing much clay or organic matter, and enters into the calculation of the heat conductivity as an important factor.

The usefulness of the information gained by this investigation consists in pointing out the changes—heretofore unknown—in heat conductivity of a soil to be expected when the moisture content and packing are varied, rather than in furnishing rigid constants which may serve to calculate accurately the heat conductivity and diffusivity of a soil under any given conditions.

The heat capacities (specific heats) of dry soils are not greatly different, and if it were merely a question of ascertaining the moisture content and then calculating the specific heat of the mixture and estimating the heat conductivity from the individual heat conductivities of soil-grain material and of water, the problem would not be difficult. But, as shown above, the degree of contact secured between soil grains depends upon several factors which are not capable of accurate measurement or control even under laboratory conditions. The packing of a soil as well as its crumb structure (soil-grain clusters) varies from point to point in the soil, varies with the moisture content, and with the temperature. The proportion of fine grains to large grains in a soil also influences its behavior toward heat passage, since the finer grains may wedge between the larger and serve to make contact between them. Consequently it is not practicable to say beforehand what may be expected with any individual soil sample, without experimenting directly with that particular sample.

* See Bull. No. 50, Bureau of Soils, U. S. Department Agriculture.

THE SEXAGESIMAL SYSTEM AND THE DIVISION OF THE CIRCLE.

By G. A. Miller.

The division of the hour and the degree into 60 equal parts, called minutes, and the minute into 60 equal parts, called seconds, keeps fresh in our minds the fact that the ancient Babylonians used 60 as a basis of numeration. Less than ten years ago all seemed to agree on the probable origin of this system. It was assumed that the ancient Babylonians supposed that there were only 360 days in a year and hence divided the circle so that one day corresponded to each division. In support of this hypothesis it was pointed out that the ancient Chinese divided the circle into 365¼ parts in their *Tcheou pei*, and that this work could not have been written before 213 B. C.; but at this early date the Chinese were already acquainted with the year of 365¼ days. From the assumption that the circle was divided into 360 equal parts before the origin of the sexagesimal system, and the fact that the radius of a circle can be applied exactly six times as a chord of the circumference, it was easy to account for the base 60.

In recent years this question has received considerable attention and many arguments have been advanced against the given hypothesis as regards the division of the circle. These arguments appear convincing, but it is not so easy to replace the old theory by one which is free from objections. In the third [edition] of his classic "Vorlesungen über Geschichte [der] Mathematik" (1907, volume I., page 37) Moritz Cantor accepts the hypothesis that the base 60 was selected as a consequence of the mingling in the Babylonian country of two ancient civilizations, one employing 10 and the other 6 as a base of numeration. In view of the difficulties which this hypothesis entails, efforts have been made to find a more plausible one.

Prof. Edmund H. Hoppe, Hamburg, Germany, has recently advanced such a hypothesis* and has given a large number of historical facts tending to its support. He assumes that the normal angle among the ancient Babylonians was an angle of an equilateral triangle and that it was observed at an early date that six such angles cover the entire area around a point. Hence the number 6 assumed great importance, being regarded to stand for completeness. The base 60 could then have easily resulted from a division of the normal angle into ten equal parts. After this base was established, alongside the much older base 10, the normal angle itself was divided into 60 equal parts, and this led to the division of the circle into 360 equal parts.

Whether this hypothesis will be generally accepted remains to be seen. The fact that the ancient Babylonian wheel had six spokes while the ancient wheels in Egypt and Greece had only four tends to support the hypothesis that among the former an angle of 60 deg. was regarded as normal, while the right angle was regarded as normal among the latter. At any rate, the hypothesis advanced by Prof. Hoppe tends to throw additional light on a question which relates to our daily experiences, but had not received a satisfactory answer.—Science.

* Archiv der Mathematik und Physik, vol. xv. (1910), p. 304.

Before the recent meeting of the American Society of Mechanical Engineers, Prof. Charles M. Allen described a complete series of tests on a 2-inch meter, to determine whether a Venturi meter is sufficiently accurate under all conditions encountered in practice to be used to measure boiler feed. The apparatus was set up in the most convenient way, not only for weighing the water used, but also for heating it before it passed through the meter, and for pumping. Four sources of supply were used—an injector, a duplex pump, a triplex power pump, and a pressure tank—all drawing water from a pit having a steam line to heat the water. As the capacity of the pit was large, an even temperature could easily be maintained. The water was discharged into 5,000-pound weighing tanks after passing through the meter. Cold-water tests were first made, to determine the co-efficient of the meter, followed by tests with conditions the same as those in boiler-rooms, the temperature ranging from 80 to 180 deg. Fah., while the pressure also was varied by different arrangements of the auxiliary apparatus. The results obtained showed that the meter tested was best adapted for use in a plant of over 200 horse-power, and, as the maximum and minimum variations noted were 3 and 9.82 per cent, respectively, the Venturi meter is adapted to measure hot water, provided the proper size is used.

HALLEY'S COMET.—II.*

BY FAR THE MOST INTERESTING OF THE PERIODIC COMETS.

BY GEORGE F. CHAMBERS, F.R.A.S.

Concluded from Supplement No. 1788, Page 239.

THE physical appearance of Halley's Comet at the 1835 apparition seems to have been in many respects very remarkable, and, did the statements made not emanate from some of the most distinguished astronomers of the time, it might be permissible to distrust them. It is impossible, however, to distrust anything stated by such men of skill and high character as Bessel, J. Herschel, W. Struve, and Maclear. Struve compared the appearance of the nucleus about the end of the first week of October to a fan-shaped flame emanating from a bright point; and subsequently to a red-hot coal of oblong form. On October 12th it appeared like the stream of fire which issues from the mouth of a cannon at a discharge and when the sparks are driven backward by a strong wind. At moments the flame was thought to be in motion or exhibiting scintillations similar to those of an Aurora Borealis. A second small flame forming a great angle with the principal one was also remarked. On November 5th the nebulosity independently of the flames (two of them being visible) had a remarkable arched form somewhat resembling a "powder horn." These phenomena, under different and varying names, were seen and commented upon by other astronomers, British and foreign. The previous installment by Admiral Smyth would seem to represent fairly well all the remarks made by the various astronomers just cited.

I have given these details respecting Halley's comet in 1835 at some length, thinking that they might be useful as hints as to what to look for in 1910.†

It will be interesting to consider what we know of the history of this comet anterior to the apparitions already mentioned. Halley, we have seen, satisfactorily traced back his comet to 1531, but since his time it has been traced very much farther backward, through a range indeed of some 14 centuries or more, first by the labors of Hind, and Laugier, and quite recently by those of Cowell and Crommelin confirming Hind for the most part, and enlarging his results. The years in which identification may be regarded as more or less certain are the following:‡

Year.	Interval in Years.	Year.	Interval in Years.
B. C. 11.8	77.8	989.7	76.5
A. D. 66.0	75.1	1066.2	79.0
141.2	77.2	1145.3	77.6
218.2	77.0	1222.9	79.3
295.2	78.6	1301.8	77.0
373.8	77.6	1378.8	77.6
451.5	79.3	1456.4	75.2
530.8	76.5	1531.6	76.1
607.3	77.5	1607.8	74.9
684.8	75.6	1682.7	76.5
760.4	76.8	1759.2	76.7
837.2	75.0	1835.8	74.5?
912.2	77.4	1910.3?	...

Cowell and Crommelin have found themselves justified in adding to this table, backward, the years B. C. 87 (May) and 240 (May); with no identification possible for the intermediate return in June, 163 B. C., though comets are vaguely mentioned in the years 166 and 165.

We owe the observations which have made these identifications possible mainly to Chinese records, supplemented, more or less, by European monastic chroniclers of various sorts and kinds, and by a few private authors. It would be tedious to transcribe any of the originals of these, even in an abridged form; indeed, in point of fact their language is already generally so curt as to be incapable of abridgment, so a concise digest is all that will be offered to the reader and this will be often given in the language of Hind§ and chronologically backward.

* "The Story of the Comets Simply Told for General Readers." By George F. Chambers, F.R.A.S. Oxford: at the Clarendon Press. 1909.

† Drawings by Bessel will be found in the Ast. Nach., vol. xiii, Nos. 300-2, Feb. 10, 1836. Reference may also be made to the Memoirs of the Astronomical Society, vol. x (drawings by C. P. Smyth); Sir J. Herschel's Results of Astronomical Observations at the Cape of Good Hope; and Struve's Beobachtungen des Halleyschen Kometen.

‡ This table is from Hind, but altered where necessary to embrace the researches of Cowell and Crommelin. It should here be mentioned that some share of credit for these identifications is due to the French astronomer Laugier. (Comptes Rendus, vol. xxiii, p. 183. 1846.) Nor should the labors of Pingré and Burckhardt be forgotten in this connection.

§ Month. Not. R.A.S., vol. x, p. 51. Jan., 1850: The Comets, pp. 50-57.

Halley surmised that the great Comet of 1456 was identical with his, and Pingré converted Halley's suspicion into a certainty. This comet was described by the Chinese as having had a tail 60 deg. long, and a head which at one time was round, and the size of a bull's eye, the tail being like a peacock's!

At the preceding return in 1378 the comet was observed both in Europe and China; but it does not appear to have been as bright as in 1456.

In 1301 a great comet is mentioned by nearly all the historians of the period. It was seen as far North as Iceland. It exhibited a bright and extensive tail which stretched across a considerable part of the heavens. Hind rejected the European observations of 1301, finding them to be of no good compared with the Chinese observations which proved consistent —a reversal of 20th-century preferences!

The previous apparition was for some time a matter of doubt. Hind treated as Halley's a comet which appeared in July 1223, and was regarded as the precursor of the death of Philip Augustus, King of France. The records are vague and inadequate; and Cowell and Crommelin have given the preference to a comet which was seen in August and September 1222 and which passed its perihelion probably in September. The Waverley Abbey Annalist says that in the months named a fine star of the first magnitude, with a large tail, appeared. When first seen it was near the place where the Sun sets in December. The Chinaman Ma-tuan-lin says that on September 25th it came from η Bootis. The tail was 30 cubits long, and the comet perished in two months. The question of the identification of one of these comets with Halley's is one of the few instances in which Cowell and Crommelin have dissented from Hind's identifications by deciding in favor of the Comet of 1222 in preference to Hind's 1223.

In April and May 1145 the European and Chinese chroniclers record a comet with a tail 10 deg. long, whose course among the stars from the end of April to the beginning of July is stated by Hind to have been perfectly in accord with the computed path of Halley's Comet, supposing the perihelion passage to have taken place about the third week in April. The Chinese accounts seem to speak of the July comet as being different from the April and May one, but whether this was so or not cannot be determined with any certainty. Hind seemed to regard the two to be one and the same.

In April of the year 1066, the year in which the Norman Conquest took place, a remarkable comet attracted the attention of all Europe. In England it was viewed with especial alarm and the success of the Norman invasion and the death of Harold were attributed to the comet's baneful influence. Zonares, the Greek historian, in his account of the reign of the Emperor Constantinus Ducas (whose death occurred in May 1067) describes a comet which was as large as the full moon, and at first was without a tail, on the appearance of which, it (which presumably means the head) diminished in size. The transformation accords with the Chinese accounts, which describe the comet's path among the stars in Chinese fashion with great elaboration. The Chinese say that this object was visible for 67 days, after which "the star, the vapor, and the comet" all disappeared. It seems fairly certain that this was Halley's Comet. At any rate it was immortalized in the famous Bayeux Tapestry.

In 989 a comet was observed in China which is mentioned also by several Anglo-Saxon writers. Burckhardt, the French computer, investigated its orbit and found that the elements bore a considerable resemblance to those of Halley's Comet. The perihelion passage was found to have occurred about September 12th.

Halley's Comet certainly appeared in 912, but there were two comets in this year and Cowell and Crommelin differ from Hind in the identification, Hind selecting the earlier one and Cowell and Crommelin the later one, which appeared in the autumn.

Halley's Comet should have appeared in 837. There certainly was a comet in this year, but a comparison of the European and Chinese accounts, taken literally, implied that there were two comets in this year, one in perihelion in February and the other in April. The latter would seem to have been a most imposing object, but in Hind's opinion it could not have been Halley's Comet. The Chinese records indeed imply that there was a third or even a fourth comet in that year, in the months of June and September, but we need not discuss this question, which probably involves some misconceptions and which does not concern us in discussing Halley's Comet.

A comet appeared in 760, which without any doubt whatever was Halley's. It is recorded in detail both by European and Chinese annalists, and the orbit has been calculated and identified by Laugier. By European writers we are told that a comet like a great beam and very brilliant was observed in the 20th year of an Emperor Constantine, first in the E. and then in the W., for about 30 days. The Chinese gave a visibility of two months. Laugier calculated the perihelion to have occurred on June 11th.

In 684 the Chinese record a comet observed in the W. in September and October. Hind pointed out that this statement would accord with the course of Halley's Comet when the perihelion occurs about the middle of October, and, as the epoch for the reappearance of the comet is about what it should be, there is "a fair probability" in favor of the identity.

A comet observed by the Chinese in the constellations Auriga, Ursa Major, and Scorpio in 608, was regarded by Hind as probably Halley's, who said that the track assigned would harmonize with a perihelion passage occurring about November 1st. Cowell and Crommelin, however, identified the Comet of 607 (1.) as Halley's.

The previous return should have occurred about 530. There was a comet in that year, and none of the few circumstances connected with it recorded by the European chroniclers is contradictory to the theory which implies that the comet was Halley's. The Chinese records are silent as regards this year.

A comet appeared in 451, as to which there is little doubt that it was Halley's, according to the investigations of Laugier. It was seen in Europe about the time of the celebrated battle of Châlons, when the Roman general Aëtius defeated Attila, the leader of the Huns, who had been ravaging central Europe. In China the comet was observed from the middle of May till the middle of July during which period it moved from the Pleiades into Leo and Virgo, a track which agrees with the path which Halley's Comet would have followed if its perihelion passage took place on July 3d.

In 373 the Chinese annals record a comet in Ophiuchus in October, which Hind thought would fit in with the probable position of Halley's Comet if the perihelion passage took place about the beginning of November. But another Chinese authority records a comet much earlier in the year, namely in March and April, which must have been visible all through the summer if it were the same as the October comet.

In 295 there was a comet observed in China, the identity of which with Halley's, Hind thought to be "nearly certain." It seems to have been visible in May after perihelion passage at the commencement of April.

In the year 218 a large comet is recorded both by European and Chinese chroniclers. Dion Cassius describes it as a very fearful star with a tail extending from the W. towards the E. The Chinese catalogue of Ma-tuon-lin gives it a path exactly in agreement with the path which would be followed by Halley's Comet when the perihelion falls about the first week in April. The description given is that it was "pointed and bright."

In 141 the Chinese observed a comet in March and April, "6 or 7 cubits long" and of a bluish-white color. The elements of a comet following a path such as that described in some detail by the Chinese annalist would not be widely different from those of Halley's Comet; and the comet is the only one recorded about this epoch.

The preceding apparition should have taken place either in the summer of 65 or in the following winter of 65-66. The Chinese record two comets: one in July 65 which remained visible for 56 days, and the other in February 66 which remained visible 50 days.

Hind suggested that most likely the last-named was Halley's Comet, if the perihelion passage took place at the end of January, and Cowell and Crommelin have definitely confirmed this. Not improbably this comet was the sword-shaped sign recorded as having hung over the city of Jerusalem before the commencement of the war which terminated in the destruction of the Holy City. Josephus says that several prodigies announced the destruction of Jerusalem: "Amongst other warnings, a comet, of the kind called Xiphias, because their tails appear to represent the blade of a

sword, was seen above the city for the space of a whole year." Josephus rebuked his countrymen for listening to false prophets while so notable a sign was in the heavens.

Dion Cassius mentions a comet which seemed to be suspended over the city of Rome before the death of Agrippa. The date would be B. C. 11. The path of this comet was recorded in great detail by the Chinese, and Hind thought that the records afforded "the most satisfactory proof that they belonged to the Comet of Halley." The third week in October was suggested for the perilion passage. The comet was lost in the Sun's rays 56 days after its discovery.

Cowell and Crommelin have made systematic efforts to trace Halley's Comet back further, and with some success, and it is not beyond the bonds of possibility that further identification will reward research because the Chinese records go back for six centuries before the Christian era, and besides them there exists a sprinkling of European observations, although all these latter are very much lacking both in precision of language and precision of dates.

THE PSYCHOLOGY OF PEOPLES.*

By Prof. R. S. Woodworth.

All in all, the discovery of true inherent differences between races and peoples is an intricate task, and if we turn to the psychologist to conduct an examination of different groups, and to inform us regarding their mental differences, we must not allow him to present a hasty conclusion. His tests must be varied and thorough before we can accept his results as a serious contribution to this difficult subject. The psychologist may as well admit at once that he has little to offer; for, though the "psychology of peoples" has become a familiar phrase, and though books have been written on the subject, actual experimental work has so far been very limited in quantity.

One thing the psychologist can assert with no fear of error. Starting from the various mental processes which are recognized in his text-books, he can assert that each of these processes is within the capabilities of every group of mankind. All have the same senses, the same instincts and emotions. All can remember the past, and imagine objects not present to sense. All discriminate, compare, reason and invent. In all, one impulse can inhibit another, and a distant end can be pursued to the neglect of present incitations. Statements to the contrary, denying to the savage, powers of reasoning, or abstration, or inhibition, or foresight, can be dismissed at once. If the savage differs in these respects from the civilized man, the difference is one of degree, and consistent with considerable overlapping of savage and civilized individuals. The difference of degree calls for quantitative tests. But besides the traditional classification of mental powers, there is another of perhaps greater importance in studying differences between men. One individual differs from another not so much in power of memory, or of reasoning, or of attention, or of will, as in the sort of material to which he successfully applies these processes. One gives his attention readily to mathematics; he remembers mathematics easily; he reasons well on mathematical subjects; his will is strong in excluding distracting impulses when he is in pursuit of a mathematical goal. He may show none of these powers, in a high degree, in relation to music, or business, or social life; whereas another, totally inefficient in mathematics, may show equal powers of mind in another subject. The capacity to handle a given sort of subject matter is in part determined by native endowment, but is very responsive to training, and therefore is hard to test, because only individuals with equal training in any subject can be fairly tested and compared as to their native capacity to handle that subject. Thus it becomes hard to contrive a test for musical or mathematical or mechanical endowment which could fairly be applied to races having diverse trainings in these lines. This difficulty, moreover, infects our tests for such general powers as memory or reasoning, for a test has to deal with some sort of material, and success in passing the test depends on the familiarity of the material as well as on the power of mind which we design to test. We may suppose, indeed, that all of our tests, founded as they are on material which is familiar to us will be more or less unfair to peoples of very different cultures and modes of life. The results of our tests need to be discounted somewhat —exactly how much we cannot say—in favor of the primitive peoples tested.

The production of pig iron in Belgium in 1909 amounted to 1,632,000 metric tons, of which 1,386,800 tons was Bessemer and basic iron, 89,000 tons foundry iron and 156,590 tons forge iron. The exports of pig iron were 19,000 tons and the imports 477,000 tons. The imports of iron ore into Belgium in 1909 were 4,383,892 tons, as against 3,342,404 tons in 1908, practically all pig iron being made from imported ore.

* Abstract from an address delivered before the American Association for the Advancement of Science.

SCIENCE NOTES.

An impression has been widely circulated throughout the country that a considerable portion of the collections made by the Smithsonian African Expedition under the direction of Col. Theodore Roosevelt will be distributed among the museums of the country. Before the expedition started, it was understood that the collections should be largely limited to such material as was needed for a full exhibition and study series for the United States National Museum. This would include the collecting of a number of specimens of each animal, in order that the characteristics of each species would be represented. It will not be possible to break up these series, as it would greatly diminish the value of the collection. The skins of the large game animals are now being prepared for permanent preservation, and will soon be in shape for study and comparison. Arrangements are also being made to mount a portion of them for exhibition to the public.

The chemical behavior of the elements indicates that their energy content is very great, and it is probable that the matter of an atom is in a state of continual movement. This subject is considered by N. N. Beketov in an attempt to explain the properties of radium. We learn that although in general the atoms represent very stable systems, yet this internal energy may be the cause of their decomposition, as is the case with radium. In the various series of elements, increase of atomic weight is accompanied by increase of the atomic energy, and this increase is especially great if the atomic volume increases at the same time; consequently, elements with high atomic volumes are extremely reactive. The atomic energy is probably composed of the real chemical energy—which becomes apparent in chemical reactions—and of the energy of movement of the smallest particles composing each atom. On decomposition of the atoms, this energy of movement is converted into other forms of energy, as is observed in the case of radium.

In an article published in the Phys. Zeitschr., V. J. Laine states that on August 3rd, 1908, he observed during a thunderstorm a well-defined primary rainbow together with a secondary bow. The bows were continuous from one horizon to the other, and whenever a peal of thunder was heard it was noticed that the colors of the primary, and especially of the secondary bow were strongly affected, and also that the color boundaries and the edges of the bows were quite effaced. At the same time the different colors were very indistinct, and the whole rainbow oscillated very quickly. This happened every time it thundered. That the effect was due to the thunder and not to the lightning was seen from the fact that the time between the observation of a flash and the hearing of the thunder was from 20 to 5 sec., and during this time the phenomenon was not observed, but it began at almost the same instant that the thunder was first heard. At first the primary bow was very bright; the red then disappeared almost entirely, and the violet showed a great increase in intensity. Below the violet was a distinct dark space, especially marked in the case of the secondary bow, and below this was seen a small greenish-violet secondary bow. Then the oscillation occurred, and various other color effects and peculiarities were noticed. An explanation of the observed effects is to be found in the variation of the size of the drops in the rainbow, according to the theory of the rainbow given by J. M. Pertner in his "Meteorologische Optik." From this it appears conclusive that the effect of the thunder is to increase the size of the raindrops. It is possible that the thunder peals cause two or more drops to coalesce.

TRADE NOTES AND FORMULÆ.

[The Editor of the Scientific American Supplement does not guarantee the following recipes. They are taken from so many diverse sources that to test each one would involve much experiment. The formulæ are published largely by way of suggestion. Chemicals vary so much that in many cases the proportions given must be changed to obtain the desired result.]

Böttger's Red Ink (indelible) consists of carmine rubbed down with solution of waterglass and diluted with solution of waterglass. To be kept in tightly-closed vessels.

Carmine Solution for Microscopic Purposes (according to Cuccati).—30 parts of the finest carmine and 100 parts of crystallized carbonate of soda are rubbed down, and with 750 parts of distilled water brought to a boil in a porcelain dish. When solution is completed, add carefully to the cooled fluid: 50 parts of alcohol, 50 parts of 20 per cent acetic acid, 20 parts chloral hydrate, and enough distilled water to bring the whole up to 1,000 parts.

Bouillon Soup Tablets.—Finely chopped meat, absolutely freed from fat, is boiled in a saucepan with a little water and some salt, until a sample taken out becomes a solid mass on cooling. The addition of 5 per cent of the weight of meat in gelatine, expedites the solidification. The fluid is poured hot into little tin molds, in which it solidifies into tablets. These, like chocolate tablets, are wrapped in tin foil or paraffine paper.

Lemon Juice, to Preserve.—Take 25 fresh, medium-sized lemons and one orange, peel them thinly and macerate the peel, finely cut up, for about 6 hours with 1500 grammes of 96 per cent alcohol. Press the juice out of the lemons, without filtering it, mix it with the alcoholic extract and stand it aside for about 8 days, shaking it frequently. After filtration we shall obtain, as a rule, a clear fluid, in which about 0.1 gramme of vanilla may be dissolved. If the filtrate is not clear, add alcohol until it clears.

Nickeled Cuts.—By means of a weak galvanic copper positive, a thin copper negative is produced. This must be again coated with silver, i. e., just made white, or in any other manner the surface transformed into sulphate of silver or better still, iodide of silver. This negative is then suspended in a quick-acting nickel bath and a very thin coating of nickel deposited on it. Now place the cut in a copper bath and reinforce it with copper to the desired thickness. The positive thus obtained can readily be separated from the negative, and is finished up as usual. By this means, we obtain an absolutely sharp cut, the upper stratum of which, of any desired thickness, is nickel. Such plates will stand the largest editions and are not sensitive to color.

Paper for Artificial Flowers (Bianchi patent).—Chinese rice paper (papyrifera) is placed for 1½ to 2 hours in the following solution: A pulverized mixture of about 125 parts saltpeter, 125 parts alum, and 125 parts carbonate of potash is put into about 3,750 parts of distilled or rain water, thoroughly stirring it; then boil the whole for a half hour, allow it to stand until the solution has cooled to about blood heat, then filter it through muslin. To the clear fluid thus obtained, we add, in this warm condition, 8 teaspoonfuls of wood alcohol and about 30 parts of pure glycerine. When the rice paper has lain for about 1½ to 2 hours in this solution, allow it to drain, and before it dries gently press out the superfluous fluid with the hands. Spread out in separated sheets in a warm, dry place for about two hours; it can then be colored. It is advisable to mix the colors with a small addition of wood alcohol and glycerine; for about 3,750 parts of coloring matter, about 375 parts of alcohol, and 375 parts of glycerine. The color is to be squeezed gently out of the paper, which is then spread out in separated sheets and again dried for two hours in the shade. By means of stamps or by other methods they are given the proper shape. The flower parts, or leaves, are lightly immersed in melted ordinary beeswax, rolled between the fingers and otherwise treated in the ordinary manner.

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